Wildlife Research

Wildlife Branch

1985

April 1986

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1985

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NEW PUBLICATIONS

Addison, E.M., D.J. Forrester, R.D. Whitley, and M.M. Curtis. 1985. Oxyspirura youngi sp.n. (Namatoda: Thelaziidae) from the Patas monkey, Erythrocebus patas. Proc. Helminthol. Soc. Wash. 53: 89-93.

Davis, R.A., R.N. Jones, C.D. MacInnes, and A.J. Pakulak. 1985. Molt migration of large Canada geese on the west coast of Hudson Bay. Wilson Bulletin 97: 296-305.

Dunn,E.H., D.J.T. Hussell, and J. Siderius. 1985. Status of the Great Blue Heron, Ardea herodias, in Ontario. Canadian Field-Naturalist 99: 62-70.

Eadie, J., and H.G. Lumsden. 1985. Is nest parasitism always deleterious to Goldeneyes? The American Naturalist 126: 859-866.

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Hussell, D.J.T. 1985. Clutch size, daylength and seasonality of resources: Comments on Ashmole's hypothesis. Auk 102: 632-634.

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MacDonald, D.W., and D.R. Voigt. 1985. The biological basis of rabies models. Pp. 72-108 in P.J. Bacon, ed. Population dynamics of rabies in wildlife. Academic Press, London.

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Ontario: morphological relationships and origins. Canadian Journal of Zoology 63: 1130-1137.

Voigt, D.R., R.R. Tinline, & L.H. Broekhoven. 1985. A spatial simulation model for rabies control. Pp. 311-349 in P.J. Bacon, ed. Population dynamics of rabies in wildlife. Academic Press, London.

SUBMITTED FOR PUBLICATION

Addison, E.M., M. Wilton, R. MacLaughlin, and M. Buss. Trends in natality and calf mortality of moose in south central Ontario. Alces 21: (in press)

Addison, E.M., et al. Parasites and diseases of furbearers. Ms submitted for publication in "Wild Furbearer Management and Conservation in North America".

Alvo, R., D.J.T. Hussell, and M. Berrill. Loon breeding success on acid lakes. Submitted to Science.

Hussell, D.J.T., and T.E. Quinney. Food abundance and clutch size of Tree Swallows, Tachycineta bicolor. Ibis 128: in press.

McLaughlin, R.F., and E.M. Addison. Tick (Dermacentor albipictus) induced winter hair loss in captive moose (Alces alces). Submitted to Journal of Wildlife Diseases.

Quinney, T.E., D.J.T. Hussell, and C.D. Ankney. Sources of vatiation in growth of Tree Swallows. Auk 103: in press.

Smith, J.D., et al. 1986. Helminth parasites of Canada lynx (Felis canadensis) from northern Ontario. Canadian Journal of Zoology 64: (in press).

PREDATORS - G.B. Kolenosky

Polar Bears

The major objectives of polar bear research in Ontario are to determine the size, discreteness and annual productivity of the provincial polar bear population. Knowledge of those parameters is required to help fulfill national and provincial obligations set forth in the International Polar Bear Agreement. Basically, the Agreement states that each signatory nation will manage polar bears and their ecosystems on the basis of sound biological knowledge. We also have a moral responsibility to manage the species wisely because more than half of the world's polar bears occur in Canada.

Polar bears, like other members of the Ursidae family have a very low reproductive capability. Thus, if numbers are reduced, either from overhunting, or habitat destruction, it may take decades for recovery. Modelling of polar bear populations indicates sustainable harvests are about 5%. Sustainable yields may be only 2-3% if adult females form part of the harvest.

In 1984, Ontario initiated a population ecology and movements study of polar bears in lower Hudson Bay. The study was part of a cooperative investigation of the species throughout Hudson Bay, James Bay, Foxe Basin and Hudson Strait. The basic objectives of the study were to assess the size, discreteness, and seasonal movements of the various subpopulations. Information about the distribution and productivity of all maternity denning areas and the age-specific reproductive parameters of the various subpopulations would also be gathered. Preliminary results from 200 bears tagged and 28 radiocollared bears suggested considerable interchange of bears between the Belcher Islands and the Ontario mainland. Because denning along the east coast of Hudson Bay and on the Belchers is not common, many of the bears annually shot on the Belchers may have been born in Ontario.

To provide additional data about members and distribution, we repeated our live capture and tagging program in 1985. Field work extended from 20 July - 9 September. Because of the persisting ice cover in Hudson and James Bays, few bears arrived before early August. Some ice was still present on Hudson Bay until 28 August.

The field program was again a cooperative effort involving the Wildlife Branch (Main Office and Research Section), the Northern Regional Office and the District of Moosonee. Participating in the field were Ken Abraham, Steve Anderson, Jim Danyluck, Craig Greenwood, Charlie Hendry, Charlie Lauer, Howard Smith, John Thompson and Ralph Wheeler. As in 1984, the cooperation and participation of the Provincial Air Service was exemplary.

. Bears Captured - One hundred and fifty-four different bears were captured a total of 158 times. Four bears were recaptured because back marks applied with spray paint had faded so completely the marks were not visible to field workers. The sex and age of the captured sample and that of the 1984 sample is shown in Table I. The major difference between the 2 years is the greater number of adult males in 1985. Adult males predominated early in the year and maintained that dominance throughout the tagging session. The apparent earlier arrival of adult males contradicts the often held belief that pregnant females and perhaps, family groups are the first to arrive on shore. Differences in proportions of males and females between the two years may be due to differences in movement patterns related to different ice conditions.

Table I. Sex and age composition of captured polar bears, Ontario, 1984 and 1985.

Year	Period of Capture	Adult		Subadult		2 Yr cub		Yrlg		COY		Totals
		M	F	M	F	M	F	M	F	M	F	
1984	20 July - 29 August	33	37	15	17	4	2	7	11	12	15	153
	% females	53		53		33		61		56		
1985	28 July - 9 September	54	31	18	3	4	7	6	3	9	19	154
	% females	36		14		64		33		68		

The mean litter size of cubs of the year of 1.4 in 1985 (N=20) was smaller ($t=2.36$, $df=34$, $P<0.03$) than the mean litter size of 1.8 (N=16) in 1984. Litter sizes of yearlings in 1984 ($\bar{x}=1.8$, N=8) and 1985 ($\bar{x}=20$,

N=5) were more similar. In 1984, we captured one female with two, 2-year-old cubs; no females with 2-year-old cubs were captured in 1985.

Population Size - Based on capture-recapture ratios, the estimated polar bear population in Ontario during late summer - early fall ranged from 650 to 987 (Table II). The higher estimates resulted when each individual bear was regarded as an independent sample; estimates were about 33% lower when individual families were grouped and treated as independent social units. Families were grouped because the probability of capturing all members of a family, if one member is captured, is much greater than the probability of capturing a single, non-associated free-ranging individual.

To be valid, one of the basic requirements of the Lincoln index or the Petersen estimate is that all sex and age groups should be equally vulnerable to capture or recapture. The problem of equal probability of initial capture cannot easily be resolved because the composition of the various sex and age groups of a free-ranging population is rarely known. However, determining equal probability of recapture of marked individuals is simpler because the composition of the marked sample is known.

Based on availability, some sex and age groups had a higher probability of recapture than others. Recapture percentages ranged from a high of 31% for subadult males to no recaptures of subadult females, 2-year-old males or single adult females. Recapture percentages were 25, 13 and 10 for adult males, females with cubs (based on the number of single adult females available), and females with yearlings, respectively. Also not recaptured were single yearlings or females with 2-year-old cubs. Few of the latter may be available, however, because separation of young before the age of two is not uncommon in lower Hudson Bay. Overall, it appeared that adult and subadult males were more likely to be captured than family groups and single adult females. Planned capture efforts for 1986 will determine if that pattern continues, or if differences were simply due to a sampling artifact in 1985.

Table II. Estimates of polar bear population based on capture-recapture ratios, Ontario, 1985.

Population Estimate $\bar{x} \pm 2$ S.E.	Method	Basis
1. 987 ± 316	"Lincoln Index" (Davis and Winstead 1980)	Each individual bear captured is treated as an independent sample.
2. 967 ± 300	Adjusted Petersen Estimate (Ricker 1975)	Each individual bear captured is treated as an independent sample.
3. 664 ± 224	"Lincoln Index" (Davis and Winstead 1980)	Each social group is treated as an independent sample. A social group = all family groups, or all other single, independent bears regardless of sex or age.
4. 650 ± 210	Adjusted Petersen Estimate (Ricker 1975)	Each social group is treated as an independent sample. A social group = all family groups, or all other single, independent bears regardless of sex or age.

Movements - Except for pregnant females that wander inland to den, polar bears vacate the coast and move out onto the ice of Hudson Bay as soon as there is sufficient ice for travel. Around Churchill, Manitoba, there is usually adequate ice cover by late November; along the Ontario coast of Hudson Bay, it may require an additional two weeks for sufficient ice to form. As ice formation progresses, the bears have access to all areas of the bay. In most years, maximum ice cover exists around early April.

A comparison of the locations of radioed females in late January and early April suggested the existance of seasonal feeding areas. In January, 7 of 8 bears located were NE of Cape Henrietta Maria compared to only 1 of 8 in early April (Fig. 1). In April, 4 of 8 were straight north of the coast between Fort Severn and the Sutton River. None of the bears were located there in January.

Another difference was the distance from the coastline. In January, the average minimum distance from the coast was 82 km (N=8) versus 56 km (N=8) during early April. In January only 2 of 8 bears were closer than 64 km, whereas in April only 2 of 8 were further than 64 km. Those values resulted even though our maximum coverage from the coast in January was only about 400 km, whereas our flight distance from the coast in April exceeded 640 km.

Our initial impression on the basis of the two flights was that the bears had moved back towards the coast between January and April. The movements of two bears that were located during both flights conformed to the same pattern. Differences in availability of seals in the different areas between the two time periods may have been responsible for bear movements.

Range Fidelity - Recapture results in 1985 indicated that many polar bears, may indeed, return to the same section of the coast each year. Of 23 different individuals or family groups recaptured in 1985, 12 (52%) were captured within 40 km or less of their 1984 capture site (Fig. 2). Although not all sex and age groups were represented, there was no indication of greater fidelity by a specific group. The smallest distance between capture points was 3.2 km for a subadult male; the largest was 233 km for an adult female with a yearling. Only two other bears were more than 100 km from the previous year's capture site.

Interjurisdictional Movements - On the basis of fall aerial surveys in Ontario and Manitoba, Prevett and Kolenosky (1982) postulated the existence of a single subpopulation along western and southern Hudson Bay. However, preliminary results from capture efforts in Ontario suggest the existence of more than one subpopulation. Since 1975, several hundred bears have been marked and released in Manitoba (Stirling et al. 1977, Ramsay and Stirling 1982). Most were tagged in the vicinity of Cape Churchill or in the Owl River denning area.

Movements of Radiocollared Polar Bears
1984 - 85

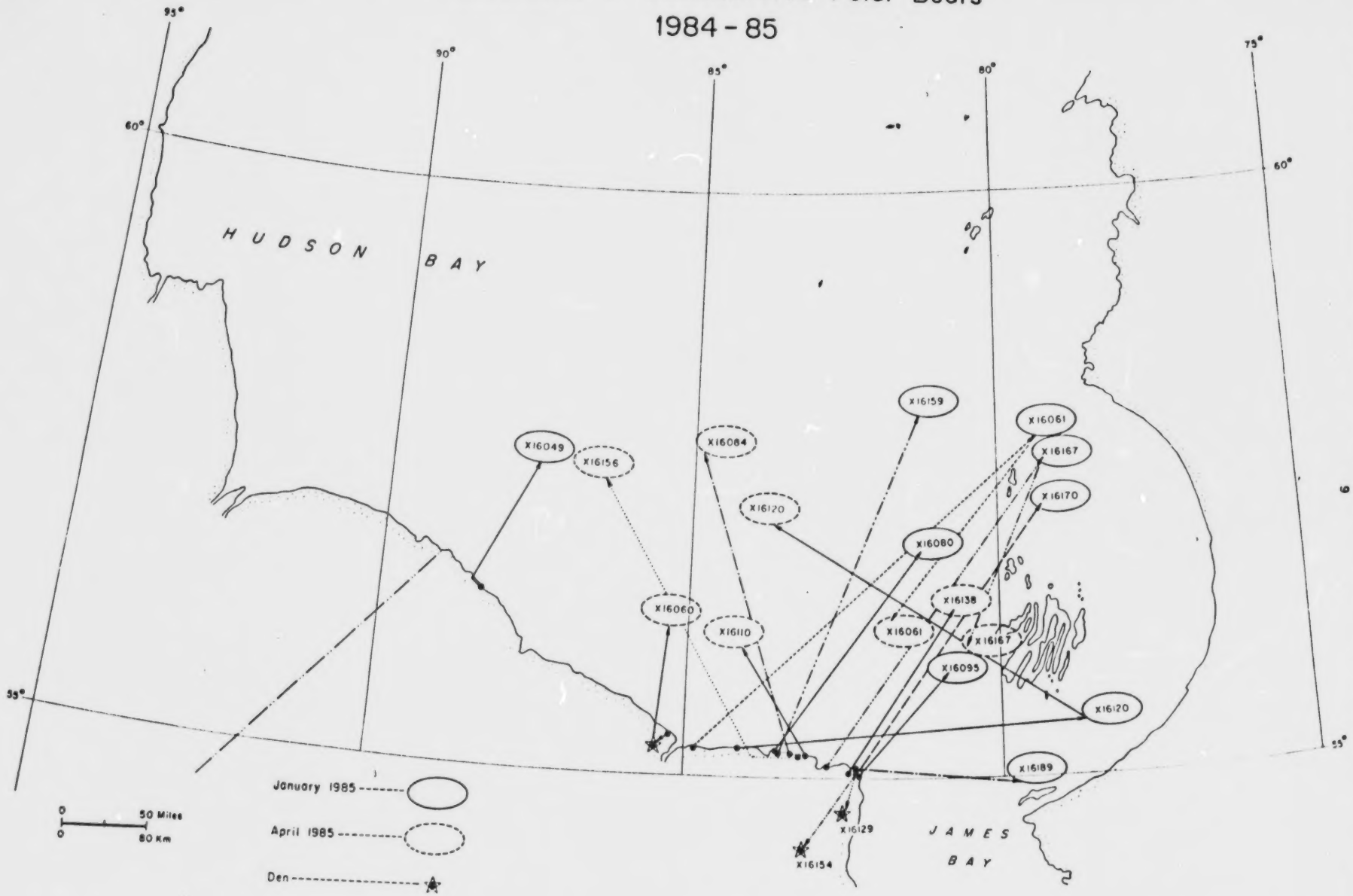


FIGURE 1

Frequency Distribution
of
Straightline Distances Between 1984 & 1985 Capture Sites
of
Polar Bears in Ontario

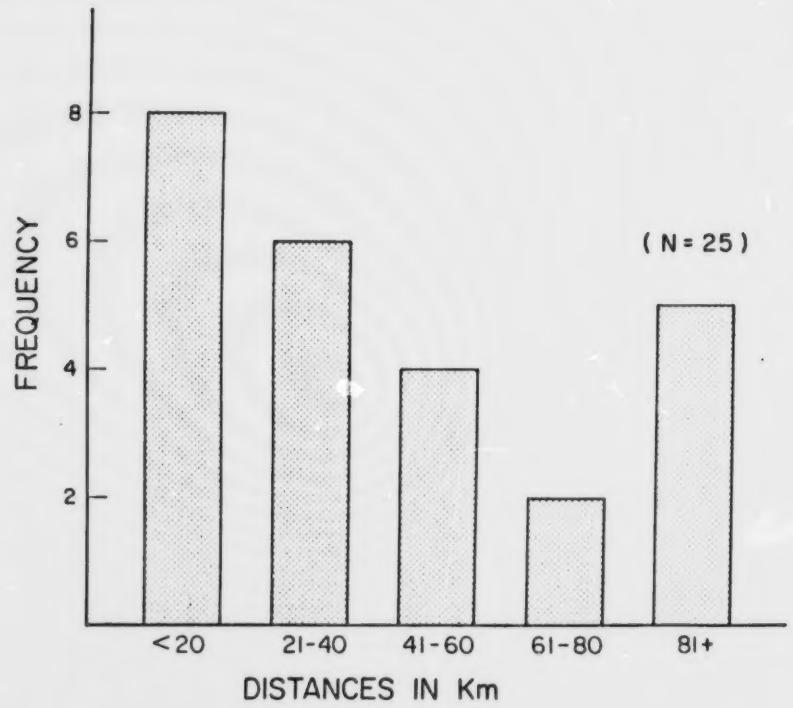


FIGURE 2

However, during two years of capturing bears along the Hudson Bay coast of Ontario, relatively few bears were recaptured in Ontario (Figs. 3 and 4). In 1984, we recaptured seven bears and in 1985 we recaptured 19 bears originally tagged in Manitoba. Of those totals, 10 were recaptured in Manitoba and 16 in Ontario. Distances into Ontario ranged from 4 to 91 km and averaged 42 km. These results indicated that travels of Manitoba bears into Ontario were apparently rather infrequent and largely confined to the extreme western section of Ontario's Hudson Bay coast. These preliminary findings lend support to the location of the existing boundary separating management zones A_1 and A_2. As further evidence that interchange between the two jurisdictions may be small, recaptures of bears tagged in Ontario by personnel working in Manitoba were minimal. Continuation of the live-capture project in 1986 will provide additional data about polar bear movements between the two jurisdictions.

Weights and Physical Condition - During summer and fall capture efforts, researchers had the impression that many bears were in poorer physical condition in 1985 than in 1984. A comparison of weights between the two years indicated that seven of the 10 different sex and age classes were lighter in 1985 (Table III). Reductions in weight ranged from 2% in male coys to 17% in 2-year-old males. Adult females were 11% lighter and adult males 9%. The only groups that were heavier were subadult males (10%), female coys (5%) and 2-year-old males (2%). The increase in weight of subadult males may have been real or it could have been partially due to differences in field aging between the two years. Completion of cementum aging will verify the accuracy of our field aging. Although most groups were lighter in 1985 than in 1984, differences were not significant.

The reason, or reasons for the apparent poorer physical condition of many of the bears in 1985 is open to speculation. If bears stay out on the sea ice for as long as they can to hunt seals, then it seems logical that they should be in superior condition when the hunting season is extended. However, we have no way of determining how successful seal hunting was in 1985 compared to 1984. If hunting success was lower, perhaps due to ice conditions, an extended hunting period may not have been adequate compensation. We also don't know if

Recorded Movements of Polar Bears
Tagged in Manitoba 1975 - 82, and Recaptured in 1984

FIGURE 3

Recorded Movements of Polar Bears
Tagged in Manitoba 1975 - 84, and Recaptured in 1985

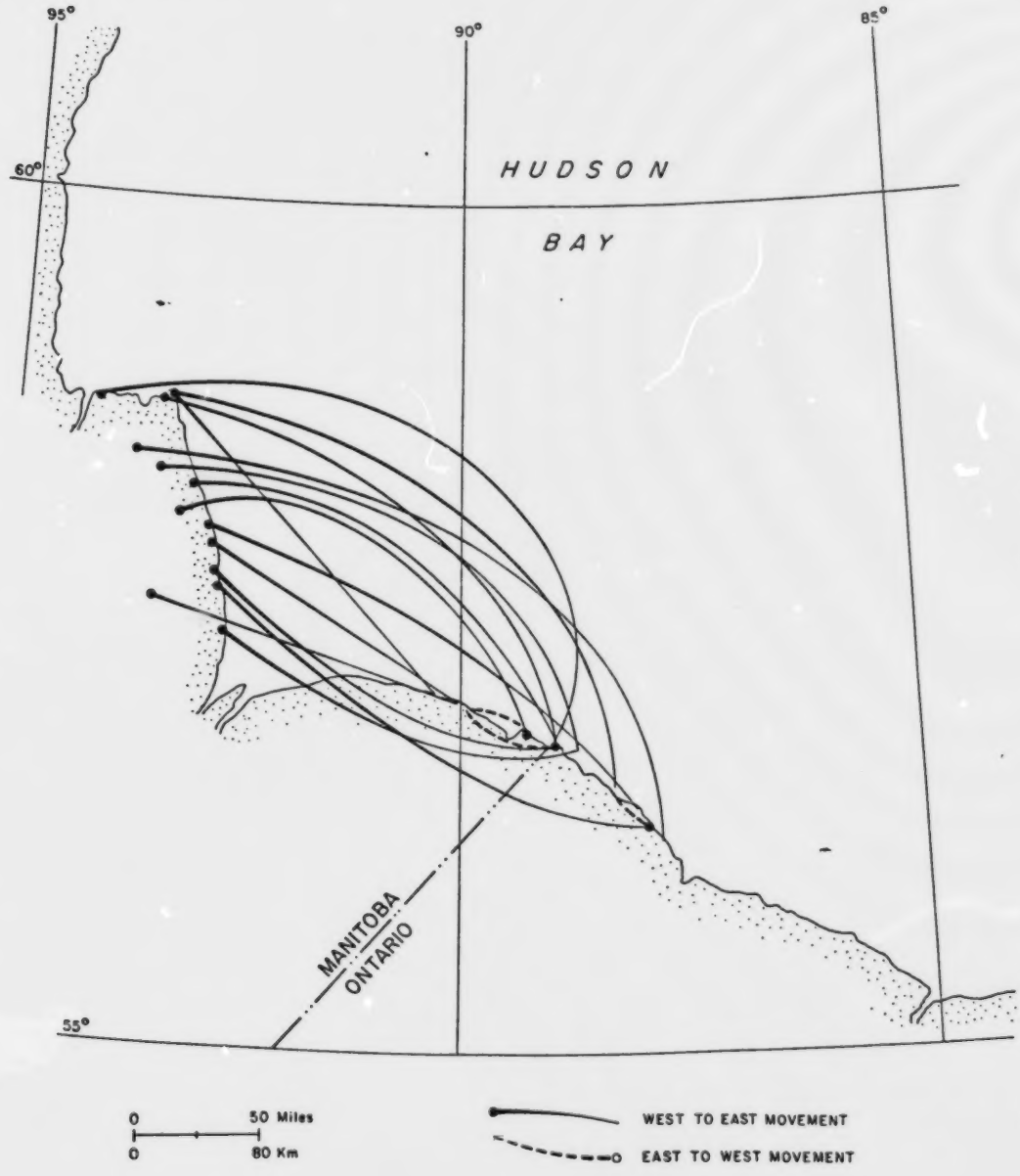


FIGURE 4

Table III. Weights of captured polar bears, Hudson Bay coast, Ontario, July - September, 1984 and 1985.

Year	COY	Yearling	2 Yr old	Subadult	Adult
			MALES (weights in kg)		
1984	83 ± 20 (N=11)	167 ± 38 (N=7)	225 ± 21 (N=4)	280 ± 41 (N=15)	508 ± 89 (N=29)
1985	81 ± 9 (N=2)	160 ± 85 (N=5)	187 ± 85 (N=3)	308 ± 42 (N=12)	463 ± 109 (N=32)
% difference	-2	-4	-17	+10	-9
			FEMALES (weights in kg)		
1984	77 ± 16 (N=13)	150 ± 11 (N=10)	200 ± 13 (N=2)	248 ± 26 (N=12)	296 ± 44 (N=33)
1985	81 ± 15 (N=12)	141 (N=1)	202 ± 2 (N=2)	234 ± 33 (N=2)	263 ± 108 (N=18)
% difference	+5	-6	+1	-6	-11

hunting success and, therefore energy intake, is similar throughout the season, or if certain seasons are especially productive. Presumably, hunting success is largely a function of seal availability which is largely determined by seal numbers and ice conditions. Perhaps, the apparent heavier ice cover in Hudson Bay in 1985 made seal hunting more difficult and resulted in more poorly nourished bears.

In addition to visible differences in physical condition, the physiology of many bears appeared to be different between the two years. Especially noticeable, were differences in responses of bears to both the capture drugs and the antagonist drug. Dosages of ketamine and rompun that were adequate in 1984 and again during the last two weeks of tagging in 1985, were not always sufficient during the early part of

1985. It is suggested that response differences may have been related to differences in the period of fasting. In 1984, most of the ice in Hudson Bay had disappeared by the time tagging commenced. Thus, many of the bears had probably been on land and had probably fasted for sometime before being captured. In 1985, the ice cover was more persistent and the arrival of bears more delayed. Because bears were so scarce, they were probably tagged as soon as they arrived on shore. Hence, their period of fasting may have been much shorter and may have contributed to an apparent greater resistance to the immobilizing drugs.

Progesterone Levels - Determination of levels of progesterone in blood serum is a standard test for pregnancy. In a sample of 20 subadult, or adult, single females captured in 1984 or 1985, 12(60%) were considered pregnant. Progesterone levels varied from 1.79 to 4.64 ng/ml. For non-pregnant individuals, levels ranged from 0.18 to 0.87 ng/ml. Females that tested pregnant weighed an average 57 kg more than non-pregnant individuals. Differences were highly significant ($t=2.92$, $df=18$, $P<0.01$). A similar relationship between superior weights and incidence of pregnancy has been demonstrated in black bears.

Productivity Surveys - Aerial surveys to assess polar bear productivity were conducted along the Hudson Bay coast of Ontario 27-28 February, 1, 11-12, 15-16 March, 1985. A total of 23 different females produced a minimum of 27 cubs. The latter estimate was the second lowest ever recorded for the seven years (1974-78, 1984-85) in which surveys were conducted. The average litter size of 1.6 was the lowest ever recorded. The decrease in production may be related to population density or the age of the producing females. Alternatively, if a high proportion of polar bears in Ontario are alternate year breeders, as has been demonstrated for polar bears in Manitoba, production would be expected to be low in 1985 because of the extremely high production in 1984. However, based on progesterone levels in the various female groups, it appears unlikely that many females reproduce that often.

Black Bear

C.A. Deary continued analyses of radio telemetry data collected from 1976 to 1980. Analyses focused on home range size, home range stability and spatial and temporal relationships among various sex and

age groups.

A paper by Deary, Kolenosky and MacInnes entitled "Spatial and temporal relationships of black bears in east-central Ontario" was prepared for presentation at the 7th International Conference on Bear Research and Management, Williamsburg, Virginia. A copy of the abstract follows:

Abstract: Spatial and temporal aspects of range use were examined for 144 different black bears (Ursus americanus) (13,182 radio locations) radio collared between 1976 and 1980 in east-central Ontario. Mean annual home range size for adult females, subadult females and yearlings was 31.4 km^2, 29.7 km^2, and 15.6 km^2 respectively. Adult males occupied larger and less stable home ranges and ranged farther between radio-locations than other sex and age groups. During the early spring, females with cubs were slower in utilizing their total annual range than non-lactating females. Ranges of adult females overlapped extensively. Sixty-one percent (N=17) of the adult females shared their range with up to three other adult females. Degree of range overlap for individual bears varied from 20 to 100 percent. Instances of temporal overlap were significantly greater after July 15 than during the spring period. Movements within home ranges appeared to be influenced by the distribution of key food sources. Adult females showed strong fidelity to specific portions of their range both seasonally and annually. Various techniques were used to assess how exclusively individual bears used their home ranges.

A second paper entitled "Winter denning of black bears in east-central Ontario" by Kolenosky and Strathearn was prepared for the same conference.

Kolenosky prepared a chapter entitled "The Polar Bear" for inclusion in the book Wild Furbearer Conservation and Management being edited by M. Novak and J.A. Baker. Kolenosky and Strathearn prepared a chapter on "The Black Bear" for inclusion in the same book.

WILDLIFE DISEASES AND PARASITES UNIT - E.M. Addison

1985 has been a year of transition for the unit, a transition from field work to laboratory and office work. Since the spring of 1980 much of our efforts have been in maintaining a captive moose herd and tick populations for study of the growth and physiology of moose and interrelationships between moose, weather, and winter ticks. Additional field studies have included the effects of weather and habitat on availability of ticks to moose in the wild, the use of twinning rates as a measure of gross productivity of moose and the description of calving sites of moose. All data collection in these studies was completed during three months of field work in 1985.

Research is sometimes perceived to "be going places" during the field phase and "stagnant" when researchers are not out where we can see them (i.e. they are in the laboratory or office). This need not be a correct interpretation but it is one which can be, and is, occasionally found. One of the most exciting challenges in the wildlife disease and parasite unit in 1985 and for the following 2-3 years is to maintain the confidence of staff as to progress being made and the value of continuing the projects through to their completion. We are still working on moose and plan to continue to do so until we can arrive at scientifically justified conclusions and have delivered our recommendations for application to wildlife management and wildlife research. Completion of a number of manuscripts in 1985 signals the start of this phase of our research.

Natality and Calf Mortality of Moose in Algonquin Park

Mike Wilton of the Algonquin Region now coordinates this study which has assessed gross productivity of moose in Algonquin Park since 1981. In previous annual reports we have promoted the potential for twinning rates to be a measure of population trend in moose and have reported a marked decline in twinning rate of Algonquin moose from a very high level (Table 1) to a level similar to most previously reported post-partum twinning rates (Table 2).

Comparison of twinning rates from spring and the following winter suggest a loss of 68-89% of twin groups during the first 7-9 months of

Table 1. Occurrence of moose calves as twins in spring[1] and winter surveys, Algonquin Park.

Year	Calving Location: islands	Calving Location: mainland	Parturient Cows collared previously (collared/total)	Twinning Rate[2]: spring(n)	Twinning Rate[2]: winter(n)	Loss of twin groups[3]
1981-82	11	0	0/11	72.7(11)	14.7 (34)	79.8
1982-83	8	1	3/9	77.8(9)	25.0 (32)	67.9
1983-84	11	0	2/11	45.4(11)	4.8 (21)	89.4
1984-85	17	7	7/24	16.7(24)	4.5 (44)	73.1

[1] All moose observed between 11 May and 31 May.

[2] Number of cows with twins/number of cows with calves x 100.

[3] Spring twinning rate - winter twinning rate/spring twinning rate x 100.

Table 2. Early postnatal twinning rates determined by aerial census of North American moose populations

Locality	Type of survey: Time	Year	Twinning rate[1] (%)	Reference
Alaska, Kenai	23 May-19 July	57-71	4-38	Bailey and Bangs (1980)
Alaska, Kenai				
1947 burn	late May-early June	77-98	22	Franzmann et al. (1985)
1969 burn	late May-early June	82-83	70	Franzmann et al. (1985)
Alaska				
interior	May-June	77-78	32	Gasaway et al. (1983)
south central	May-June	57-64	30	Rausch and Bratlie (1965)
south central	31 May-1 June	65	16	LeResche (1968)
Alberta				
northeastern	21 May-22 June	76	22	Hauge and Keith (1981)
	17 May-22 June	78	35	Hauge and Keith (1981)
Rochester	late May	76	88	Mytton and Keith (1981)

[1] Number of cows with twins/number of cows with calves x 100. Rates from some studies are for adult moose ($\geq$ 3 years of age) only, others for unaged moose.

life in Algonquin Park (Table 1). A manuscript on this topic has appeared in Alces volume 21. Copies are available upon request from Ed Addison, Mike Wilton, Rob McLaughlin or Mike Buss.

Moose Calving Sites

The objective of this study is to describe specific habitat characteristics for calving and post-partum bedding sites and to determine if cow moose select specific habitats for calving. If so, knowledge of calving habitats could lead to protection of calving sites from cutting during the appraisal of annual forest cut plans. It could also allow us to predict the level of interaction between recreational users and cow moose on "calving islands" in Algonquin Park.

Approximately 55 calving or post-partum bedding areas were marked during May from 1980 to 1985. The sites were described from late August to early November, 1985. Descriptions of each calving site relate to availability of food and shelter, perception of threats, and predator avoidance. Characters described included density of ground vegetation; species and number of trees and shrubs; % canopy cover; species quality; distance from bed to nearest shelter tree; distance and direction to nearest hiding cover; distance and direction to nearest water for escape and to shortest water escape from island sites; distance and direction to the nearest cliff; slope and direction of hills on which beds are located; position of the bed on the height of slope; visibility around the calving or bedding sites; and distances and directions to nearest ecotones and clearings. Analyses of these data will begin in 1986.

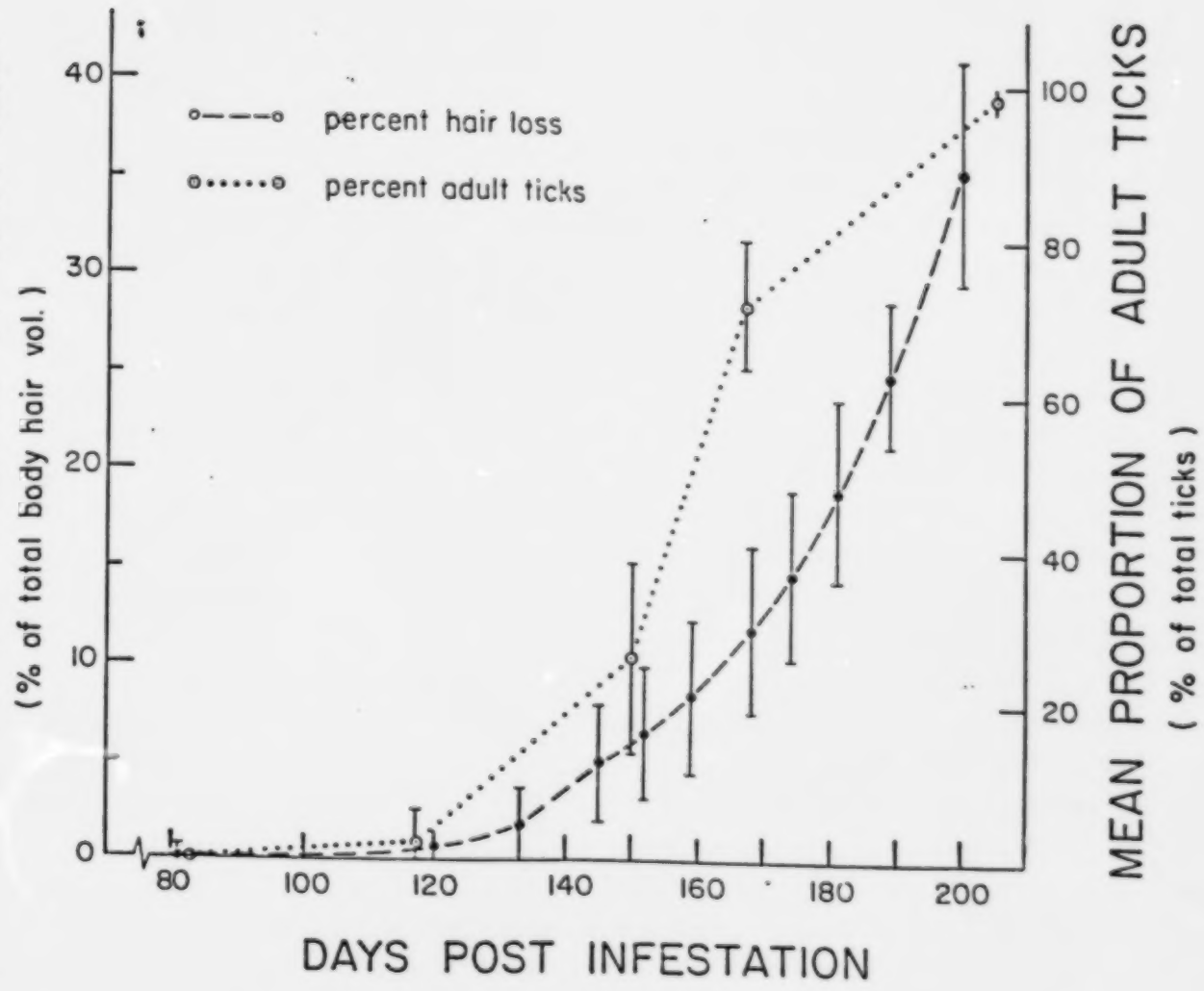
Tick (Dermacentor albipictus) Induced Winter Hair Loss in Captive Moose (Alces alces)

A manuscript with this title was submitted to the Journal of Wildlife Diseases late in 1985. The paper is based on measurements of hair loss of moose held in captivity in 1982-83. Excerpts are given below.

Methods

Five moose received a heavy infestation of about 42,000 larvae in early October, five moose received a moderate infestation of about

Figure 1. Appearance of hair loss and adult winter ticks on experimentally infested moose.



21,000 larvae, and five moose were used as controls with no ticks applied to them. One moose was infested with 19,000 larvae about a month later, on November 7 for concurrent study on tick development and survival.

To determine the progression of winter hair loss, each moose was tethered. The position, shape and size of areas of alopecia, including description of the length and condition of the damaged hair, were determined by moving fingers carefully through the hair. Results were recorded on a diagram of each moose. Observations were made every four to ten days (median 8) between January 23 and April 15, 1983. All parts of the hide were thoroughly checked for hair loss except for areas between the legs and on the belly where the extent of hair loss was estimated. The resultant diagrams were analyzed on a region by region basis with the left and right sides of the moose combined and averaged. Volume of hair lost in alopecic areas was calculated as the product of the surface area and the length of hair removed. Undamaged hair lengths from each region were recorded in September before hair damage had occurred.

Hair loss was first observed on some moose by day 20, but was negligible (less than 5% of the coat) until 134 days after infestation (mid February) (Table 3).

Differences between the amount of hair lost by heavily infested moose and that lost by moderately infested moose increased as time progressed. A Student's t-test on each time period revealed that these differences were significant after day 170. A Student-Newman-Keuls test, being less prone to error than multiple t-tests, was employed and revealed no significant difference between the two treatment groups. The 16 experimental moose could, however, be separated into three statistically distinct groups based on their temporal and spatial hair loss patterns.

Group one animals consisted of four moderately infested moose and all five of the heavily infested moose. These moose experienced a small amount of hair loss by day 135 (mid-February) followed by a nearly exponential increase in rate of hair loss through to day 195 (mid April) (Fig. 1) when 23-44% of their hair had been removed (Table 4).

In the second group of animals almost no hair was lost until

Table 3. Volumes of hair lost[a] from various body regions of nine moose infested with *Dermacentor albipictus*.

Body Region		Day Post Infestation (Approximate date)									
Locale	(%)[b]	81-123 (Jan)	134-140 (Feb 15)	142-148 (Feb 22)	151-153 (Feb 28)	155-162 (Mar 8)	164-170 (Mar 15)	172-176 (Mar 22)	178-184 (Mar 30)	186-190 (Apr 5)	193-203 (Apr 13)
Perianal	(2.5)	1(1)	11(10)	21(17)	30(15)	41(22)	49(29)	58(25)	72(25)	84(21)	89(15)
Croup	(3.8)	0(0)	0(0)	0(1)	0(1)	1(1)	1(1)	1(2)	3(3)	9(9)	21(29)
Loin	(4.0)	0(1)	3(9)	5(10)	6(11)	8(14)	12(17)	14(18)	17(19)	26(21)	35(24)
Withers	(2.4)	2(6)	4(7)	9(11)	14(17)	18(21)	24(30)	33(30)	43(28)	64(27)	77(18)
Neck	(7.0)	1(3)	12(13)	19(21)	23(21)	28(22)	34(23)	49(21)	58(19)	71(20)	79(17)
Thigh	(9.8)	0(0)	2(2)	5(5)	7(6)	8(7)	9(7)	13(9)	18(9)	22(11)	31(12)
Ribs	(15.6)	0(0)	0(0)	0(0)	1(1)	1(1)	2(1)	3(3)	4(4)	7(5)	12(7)
Shoulder	(9.2)	1(2)	5(6)	11(12)	15(15)	20(15)	25(14)	36(19)	49(18)	59(12)	66(15)

[a] Percent of total hair volume (1 S.D.)

[b] Percent of total hide area

mid-March and these moose still had 95% of their hair in mid-April (Table 4). This group consisted of one control animal and two moderately infested moose.

The third group of moose were the remaining four control animals. These animals experienced no hair loss until mid to late April, when the spring moult began. Moulted hair was observed on the ground and scattered loosely on the hides. This loss of hair could not be measured as with the tick associated alopecia, since it was an evenly distributed hair loss providing no evidence of shearing, bare patches or clumps of alopecia.

Hair loss became significant during February (Fig. 1, Table 3), but was not readily apparent from photographs until mid to late March. The volume of alopecia necessary before becoming readily apparent varied between moose and between regions depending on the degree of spatial scatter and the length of the remaining undamaged hair. Hair loss localized in one area was easier to observe than the same volume of hair loss scattered over a wide area since the remaining undamaged hair often obscured the smaller areas of hair loss. As time progressed, smaller areas of hair loss enlarged and coalesced. The most characteristic pattern on infested moose in April was hair loss posterior to the ears, anterior to a diagonal line between the saddle of the back and the chest. The most visible sign of hair loss was the contrast in colour between the dark undamaged hair and the light gray exposed undercoat. Bare areas initially appeared pink and gradually darkened to a shiny black.

Loss of hair first became apparent in photographs between days 170 and 180 on the neck and shoulders of moose which had lost between 20 and 60% of the hair of these regions (Table 3). Hair loss on the withers became apparent after day 180 and only when over 50% of the hair in this region had been lost. Other regions were of less importance as indicators of hair loss as hair loss was generally more scattered and visibility in photographs less consistent.

There was a strong positive correlation between the proportion of adult ticks on a moose and the total amount of hair lost over the whole body (Fig. 1) There was also a correlation between amount of hair lost and weight gain by moose. Although all animals showed a reduced weight

Table 4. Total hair loss, weight changes and fat levels of captive moose infested with winter ticks.

Moose	Hair loss[a] (% vol)	Weight change[b] (kg)	Pericardial fat P[c](gm)	P/H[d](%)	Abdominal fat M[e](gm)	M/B[f](%)
H4	44	12.0	270	18.2	2.09	1.07
H3	38	10.0	225	14.1	1.68	0.84
H1	32	- 4.5	186	11.7	2.02	0.93
H2	32	-23.0				
M4	31	19.5	325	20.3	4.16	1.76
H5	28	10.5				
M1	24[g]	-11.5	220	15.1	2.25	1.12
M2	24[g]	- 5.0				
M5	23	2.5				
C2	5	14.0	408	26.1	4.73	2.19
M6	4	12.0				
M3	2	24.5	360	21.3	6.68	2.58
C3	0	3.5	410	25.6	4.01	1.79
C4	0	10.5	540	34.6	6.42	2.97
C5	0	11.5				
C1	0	24.0	650	36.9		

[a] Total hair lost by April 5

[b] Total weight change between February 15 and April 15

[c] Weight of pericardium and attached fat

[d] Weight of pericardium and attached fat divided by weight of heart

[e] Weight of abdominal mesentery and visceral fat

[f] Weight of abdominal mesentery and visceral fat divided by total body weight

[g] Total hair lost by April 5

gain over the winter months the animals which experienced extensive hair loss gained an average 92% less weight during the period of major hair loss, February 15 to April 15 compared to the other moose.

Both hair loss and feed intake were significant factors affecting weight gain (multiple regression analysis). The amount of hair loss is negatively correlated and feed intake is positively correlated with amount of weight gain (partial correlation analysis). However there was also a small positive correlation between amount of hair lost and amount of feed consumed. These two results, though less than concrete, suggest that moose with extensive hair loss gain less weight while consuming more feed than moose with little or no hair loss.

There was less pericardial fat and abdominal visceral fat in moose with extensive hair loss than in moose with little or no hair loss. The combined weight of the pericardium and associated fat was on average 48 percent lower in moose with extensive hair loss than in the other moose, while combined weight of the abdominal mesentery and visceral fat was on average 55 percent lower.

Discussion

Winter hair loss was definitely related to the presence of ticks and was independent of the spring moult or the presence of mange mites. However, the amount of hair loss varied greatly between infested moose making the relationship of tick density to amount of hair loss unclear. Statistically, significant differences did not develop between the 21,000 and 42,000 tick infestation levels when all survey periods were combined, but consistent differences could be noticed during the later stages of infestation. The mean total volumes of hair lost by the heavily infested moose were consistently greater than those lost by the moderately infested moose after day 134. These differences, though of questionable significance, may indicate a trend which might be more emphatic at higher treatment levels such as those experienced by heavily infested moose in the wild.

Winter hair loss may be used as an indicator of tick infestation, but presence of ticks may be of less importance to the progression of winter hair loss than is the feeding activity or developmental stage of the majority of the ticks on the moose. The nymphal ticks remained at about the same size, as if in diapause, between October and January.

This period was followed by a rapid increase in size and a moult to adulthood. The very rapid increase in the proportion of adult ticks on the moose between mid-February and mid-April corresponded to an equally rapid increase in the amount of hair lost during this period (Fig. 1). This parallels observations on wild and captive moose from Alberta.

WE RECOMMEND THAT HAIR LOSS AS DETERMINED BY AERIAL CENSUS USING HELICOPTERS BE USED TO ASSESS THE EXTENT OF TICK INFESTATION IN MOOSE HERDS. However, tick induced hair loss on moose observed from a distance or from photographs is related to but does not always indicate actual volumes of hair lost. The proportion of actual hair removed before it becomes readily apparent from a distance varies considerably between moose and between regions on the moose. Depending on the spatial distribution of the hair loss, moose may lose up to 60% of the hair from a region before it begins to show and that may not occur until mid to late March. This has obvious implications on the timing and subsequent analysis of winter hair loss surveys done in the wild. WE RECOMMEND THAT SUCH SURVEYS BE CONDUCTED IN LATE MARCH OR EARLY APRIL, EVEN IN AREAS WHERE SNOW CONDITIONS ARE NOT IDEAL FOR LOCATING MOOSE. Prior to this time, hair loss patterns on infested moose are highly variable and would not provide an accurate assessment of the degree of tick infestation.

The effect of a heavy tick infestation on the health and productivity of a moose herd is open to conjecture. Numerous reports of tick infested moose exist in the literature and often include observations of alopecia, emaciation, weakness and death.

Anemia related to the feeding by ticks on body fluids was not indicated by an initial analysis of various blood parameters. The presence of ticks may cause a disease condition induced by something other than hair loss. However, in one of our infested moose, the presence of ticks did not seem to affect the moose in any way. This moose lost very little hair and gained more weight than any other moose. The critical difference seems to have been the absence of hair loss.

On average moose with extensive hair loss in this study consumed slightly more feed than the other moose, but were found to have much lower weight gains and fat levels. This would indicate that these moose had an increased energy expenditure or reduced energy utilization

capabilities related to alopecia. The cost in metabolic energy of maintaining a constant body temperature while partially alopecic is high, and may well explain the relatively poor condition of moose with extensive hair loss. Regelin et al. (1985) found that a "normal" two year old moose on pelleted feed in a heat chamber produced 565 kilojoules (KJ) of energy per kg $^{0.75}$ of body weight in the winter. To reduce the loss of body heat, moose are provided with a winter coat with insulative values as high or higher than that of most other mammals. Scholander et al. (1950) found that the coat of moose has insulative values ranging from about 2.3 to 3.5 watts per dm^2 at a 37°C temperature differential and these insulative values are closely correlated to the length of the hair.

A 230 kg yearling moose has a surface area of about 291 dm^2. Using the preceding data we can readily see that with all behavioural and metabolic adaptations aside, the basic daily energy requirements of 33,369 KJ for this moose would double if the moose lost 30% of its hair and was exposed to ambient temperatures of -20°C.

In wild moose during the winter, the digestable dry matter intake is low and does not meet normal maintenance requirements. Therefore the increased energy expenditure related to hair loss would necessarily come from the catabolism of body tissues. Depending on the amount of hair lost and environmental conditions, the increased rate of catabolism would weaken the moose, making it more susceptable to predation, disease and in severe cases, could result in catabolic shock and death.

Productivity of Winter Ticks

Our studies on winter ticks have been chosen with the objectives of finding if ticks are harmful to moose, if so, how and when the damage occurs and what can be done about it. Through these studies we have hoped for a general understanding of important factors which would allow us to predict the future impact of winter ticks on local moose populations. One important factor is to understand the gross and net productivity of female winter ticks which drop from moose from March - May. How many young can ticks produce? How many of the young which are produced will survive until the time of transmission to moose in autumn?

Summer survival of larval winter ticks and its importance to moose

management were briefly discussed in the 1984 Wildlife Research Annual Report. In 1981 we wrote a paper describing egg production of partially fed female winter ticks from road-killed moose. The purpose of the present study is to describe the biology of egg laying in fully engorged winter ticks which have detached from moose in spring.

Female winter ticks were collected after they had dropped from captive moose. The ticks were weighed and held in incubators at high humidities and temperatures of 20°C and 24°C. These artificially high temperatures (when compared with field conditions in April and May) were chosen in order to compare the gross productivity of winter ticks from moose with other ticks.

Ticks in this study weighed an average more than 800 mg (Table 5) which is exceedingly large for engorged winter ticks. Engorged female winter ticks from moose in Alberta are 25% smaller (600 mg) and from cattle in Texas are only about half the size (420 mg). Larger winter ticks on Ontario moose is important because larger ticks lay more eggs than smaller ticks. The average number of eggs laid/female tick varied from 6,263 to 8,255 in our various experiments (Table 5). The term "Reproductive Efficiency Index" (REI) is used to express the productivity with respect to weight of females and is the number of eggs per gram of female tick. The REI values in our experiments are similar to values reported for ticks from moose in Alberta and cattle in Texas. In other words, ticks from Ontario moose lay more eggs because they are larger and not because they are otherwise more productive than ticks studied elsewhere.

A strong immunity against ticks is acquired by some hosts with initial contact between that species of host and particular species of ticks. A strong immune response by the host may result in smaller engorged female ticks or reduced REI. In the present study we placed 20,000 larval winter ticks on three moose, two of which were each infested with 21,000 larvae the previous year and one which was naive, i.e. had no prior exposure to winter ticks. There was no statistically significant difference between the reproductive efficiencies of engorged females from these two groups (Table 5). These few data suggest that prior exposure of wild moose to winter ticks may not decrease the productivity of winter ticks from these immunologically experienced

Table 5. Factors associated with oviposition of Dermacentor albipictus

	1981		Host[b]	
			Naive	Prev. exposed
	20°C	24°C	24°C	24°C
Number of females	160	99	25	49
Weight of females (g)	0.824 (.142)b	0.882 (.124)	0.873 (.130)	0.810 (.148)
Number eggs laid	6.365 (1666)	6.263 (1530)	8.255 (1451)	7.512 (1660)
Preoviposition period (days)	13.5 (1.5)	8.8 (1.0)	- -	- -
Incubation period (days)	57.8 (5.8)	36.7 (2.3)	- -	- -
REI: # eggs/g female	7,682 (1386)	7,097 (1518)	9,443 (738)	9,236 (895)

ov.

[a] - previous exposure of moose to ticks

[b] - mean (standard deviation)

moose. This is at best speculative but appears in keeping with field observations which might encourage the view that older wild moose have no stronger immunological response against ticks than do younger moose. From a management viewpoint we would predict that (with all other factors equal) tick productivity, hence perhaps tick problems, can be just as great in an aged moose population showing little recruitment as in a young expanding population containing many moose naive to winter ticks.

The period from dropoff of female winter ticks until the start of egg laying (preoviposition period) and the incubation period are both accelerated at higher temperatures (see Table 5). With females held at a constant temperature of 20°C the average first hatching of larvae occurs 71 days after females drop from moose. Since most ticks drop off in April and May, larvae from eggs exposed to approximately 20°C might be expected by July. Detailed results of this work will be available in 1986.

Cadmium in Moose

The high toxicity of cadmium (Cd) to people from occupational exposure was identified during the 1940's. Cadmium has been demonstrated in varying levels in hares, roe deer, and moose in Sweden. Within vertebrates Cd concentrates most in kidney tissue. There is much less of it in liver and relatively little in muscle.

Concentrations of Cd increase with age of herbivorous animals and vary between areas. Differences in Cd levels in wildlife between areas may, in part, be influenced by the amount of natural Cd in the geology of the area, environmental pollution, food habits of wild herbivores in the area, and perhaps other factors.

Levels of Cd in kidney of Swedish moose were 4.36 mg Cd/kg for a small sample of moose shot and 4.59 mg Cd/kg for moose which were diseased or died an accidental death. A high Cd level in Swedish moose would be 13 mg Cd/kg. Very little was known about Cd in North American ungulates and nothing was known about Cd in wet tissues of moose.

Kidneys of 56 moose shot during the 1984 hunt in the Kearney area of Bracebridge District were analyzed for Cd. This preliminary survey was a cooperative effort of Algonquin Region, Bracebridge District, Dr.

Adrian Frank of the Swedish Veteirnary Institute and Research Section, Wildlife Branch. The results were most surprizing. Kidneys contained an average Cd level (22 mg Cd/kg) higher than the highest levels found in over 4000 Swedish moose and included 14 moose with levels in excess of 25 mg Cd/kg.

The significance of these preliminary results is difficult to assess. Elevated levels might be expected if the sample of moose was comprised of many old moose (it was), if the geology in the immediate sampling area was high in Cd, or if Cd was being carried into the area as an environmental pollutant.

This preliminary work has stimulated a provincial survey of moose and deer for Cd levels. Particular study areas which reflect factors influencing Cd levels in animals, have been chosen. For further information on the new expanded project contact Doug Hagan or Val Gloosechenko of Program Development and Audit Section, Wildlife Branch, Toronto.

Other Moose Projects

As time and staffing allow, the following projects will be completed:

1. Development of winter ticks on moose

The size and stage of winter tick change predictably from October to February. Through examination of the ticks on a moose it will be possible in some cases to determine if a moose was shot legally, or illegally after the end of the season in areas where there is a late closing date. This is an unexpected and exciting application to enforcement work of studies on development of winter ticks on moose. The project will be completed in 1986. Contact Rob McLaughlin or Ed Addison for information relating to specific enforcement cases.

2. Skelatal morphology of moose

The objectives of this project are:

a) to identify sexual dimorphism in bones of moose calves so that we may have better techniques of sexing harvested moose,

b) to determine if the size of any bones within an age group

are good indicators of body weight or of condition as otherwise judged by studies of growth, carcass fat composition, pathology, behaviour, hematology and blood chemistry.
This project was inactive in 1985 due to a shortage of funds.

3. Growth of moose

The results of this work are already being used in enforcement cases to indicate when calves stop growing in the autumn. Some people, charged with taking an "adult" when shooting a yearling in December on a calf license, are claiming that late calves are a lot larger than October calves hence more readily mistaken with yearlings.

Weekly measurements of 18 moose for chest girth, shoulder height, neck diameter, ear length, total body length and weight from late August through winter to early April will be of value in addressing these claims. This study will be completed in 1986. Contact Rob McLaughlin or Ed Addison for information applicable to specific enforcement cases.

4. Hematological and blood chemical measurements as indicators of condition of moose.

5. Internal pathology in moose infested with winter ticks.

6. Effects of weather and disease on behaviour of captive moose.

7. Rate of cooling of moose carcasses following death.

This project, with obvious application to enforcement work will be completed in 1986.

Parasites of Red Foxes

The objective of this study is to assess the potential of fox parasites to be mortality factors in fox populations or to be threats to the health of humans and domestic animals. The study, started in 1979, has been on hold due to a shortage of funds.

Lynx Parasite Study

The lynx parasite study was started in 1980-81 and completed in 1985. A manuscript describing findings will be in The Canadian Journal of Zoology early in 1986. For an overview of the results see the 1984 Wildlife Research Annual Report.

Diagnostic Services

The service provides, upon request, evaluations as to the causes of sickness and death of wildlife. A contract between OMNR and the Ontario Veterinary College (O.V.C.) in Guelph allows for detailed examination of specimens.

There are problems in submitting specimens. It takes money and time (increasingly valuable resources) to ship specimens. The answers often take longer than desired to get back to the client. This is, in part, due to demands on our resources in field offices and at Maple. However, constraints have also slowed the diagnostic work in the Department of Pathology, University of Guelph. Pathologists in Guelph are doing a good job with the available resources.

Increased diagnostic work can again be offered at Maple, in addition to University of Guelph, now that there is less field research on moose being conducted by the Parasite and Diseases Unit.

We encourage more use of the diagnostic service and will welcome suggestions as to how it can be improved.

Laboratory Services - D. Joachim

The Wildlife laboratory provided help to the other units in the section and other groups in the Ministry. Besides the everyday running of the laboratory, we were involved in the following projects.

Moose: Skeletons from specific moose were boiled and dried and tagged for further study. Hides of 5 moose were boiled in Koh for tick counts. From the numbers of ticks recovered and from other field reports of sick or dying moose lacking hair, it appears that ticks had a greater than normal adverse effect on condition of moose in the spring of 1985. Over 300 moose teeth were aged for various districts.

Deer: Deer teeth were sectioned on the isomet saw. Decalcification, staining, and aging of these sections were

unsatisfactory and a decision was made to age all deer teeth using histological methods.

Polar Bear: Much time was spent experimenting on polar bear teeth preserved in 10% formalin. The decalcification of these preserved teeth became next to impossible, hence teeth could not be cut satisfactorily on the microtome. We have since decided not to process the remaining 1984 polar bear teeth preserved in 10% formalin. WE STRONGLY RECOMMEND THAT PEOPLE DO NOT FIX TEETH WHICH THEY PLAN TO USE FOR AGEING STUDIES. Some work was carried out on the 1985 polar bear teeth stored in water. It shows great promise in being able to estimate ages through standard histological techniques and staining in Tolylene blue or Toluidine blue. Seven polar bear heads were cleaned.

Musk Ox: About two hundred musk ox teeth were cut on the isomet saw and aged using ultra violet light. A suggestion was made to Dr. Hussell to acquire some known-age musk ox teeth from Alaska to test our technique.

The laboratory has provided expertise in ageing, to various districts, regions, and outside institutions. A one week training course in ageing was given to the technician in Cochrane. A graduate student of Laurentian was also given a two week course in ageing arctic fox.

Performing necropsies, supervising of seasonal staff, purchasing and organizing supplies for the laboratory, library work, and field work were carried out routinely.

About twenty samples of hair were identified for forensic cases.

From early September to mid October time was spent in Algonquin Park helping gather data on the physiography and vegetation of moose calving sites.

UPLAND GAME AND WATERFOWL - H.G. Lumsden

Restoration of Trumpeter Swans in Ontario

In 1985 no Trumpeter Swan eggs were available from the wild stock at Grande Prairie, Alberta. Captive Trumpeters held by aviculturists were our only source of eggs. An anonamous donor gave one clutch of 7 eggs. This clutch was placed in two Mute Swan nests at Cranberry Marsh.

Pair G had successfully raised 2 Trumpeter cygnets in 1983 and 1 in 1984. They were given 3 eggs on 4 June, 1985. This female had been incubating her second clutch for 18 days and continued until 10 June when we found that the eggs had been destroyed by an unknown predator.

Pair D had raised a brood of their own cygnets in 1983, but had not been given Trumpeter eggs before. The female started incubating her first clutch on 5 May and had been sitting for 31 days when given 4 Trumpeter eggs on 4 June. On 11 June after 38 days of incubation, the first cygnet hatched. Two more hatched, probably on the night of 12-13 June, and the fourth egg was rotten. None of these cygnets survived. One cygnet disappeared on 15 or 16 June, a second between 19 and 22 June, and the third lived until 10 or 11 July when it was about 28 days of age. The carcass of this cygnet was found on 11 July partially eaten by a Snapping Turtle.

Since 1983, 10 Trumpeter cygnets hatched by Mute Swans at Cranberry Marsh have disappeared. It is likely that most if not all were taken by Snapping Turtles. In 1985 we started to control Snapping Turtles in Cranberry Marsh. By the end of August, 27 turtles had been removed. The largest weighed 14.7 kg (32.4 lbs) and the smallest 1.1 kg (2.4 lbs).

The four male Mute Swans, for which we have adequate observations, which have foster parented Trumpeter cygnets, have all shown aggression toward the cygnets when they first left the nest. This has ranged from mild pecking at the cygnet without making contact to serious attacks. Male Mute Swans have been recorded attacking their own "white" phase cygnets, but not the dark colour phase. Since Trumpeter cygnets are even paler than "white" phase Mutes, it seemed that the colour of the Trumpeters was causing a problem. In 1985, before they left the nest, we painted the Trumpeter cygnets dorsally with Nyanzol D dye (Nyanza Inc., Andover, Mass) which turned them brown. When they left the nest we saw no aggression toward them by their foster father. Before we can be sure that dying offers a solution to this problem, more controlled

experiments with both dyed and undyed cygnets are needed with additional Mute Swan pairs.

Survival of Trumpeters Since 1982

The female Trumpeter raised at Ontario Place in 1982 was missing for 19 months, but turned up at Lake Side Park near Port Credit on 29 January 1985. She is banded, but lacks patagium tags and may have been seen since, but we cannot be certain. The male raised with her spent most of the winter in Whitby harbour. In April he moved to the Shoal Point Marsh and then returned to Whitby Harbour in July.

The single surviving Trumepeter raised in 1983 which migrated to Chesapeake Bay for her first winter, remained on the Toronto waterfront throughout her second winter. She was last seen in Whitby Harbour in March.

The two cygnets raised in Cranberry Marsh in 1984 wintered on the waterfront near Port Credit. The male has not been seen so far this spring and the female was found dead on 14 March.

The experimental part of this program is now virtually complete. Serious efforts at restoration should now begin using 50 eggs per year.

Suitability of Nest Boxes for Cavity Nesting Birds

Naturalists everywhere are interested in putting up nest boxes for cavity nesting species. Their objectives may be to encourage birds to nest when they can be seen and enjoyed, or to increase stocks of desirable species such as the Bluebird. A great many box designs have been used with success but there remain problems with competition among species. Naturalists may find Starlings, House Sparrows or Tree Swallows taking over boxes intended for Bluebirds, or have difficulty pursuading House Wrens to accept boxes.

In 1977 we started experiments to find out which box features were favoured by each species. Boxes were mounted in pairs in one of which a feature was varied. The choices made by Tree Swallows, House Wrens, Eastern Bluebirds and Starlings were recorded.

Tree Swallows preferred boxes facing south as opposed to north in spite of the fact that the prevailing rain winds in May and June come from the SE. It seemed likely that of greater importance to the birds than an occasional wet nest, was windchill in excess of 1100 watts/m^2. Only 4% of the chill units in excess of 1100 watts/m^2 came from SE to SW in May and June in records from 1957 to 1980, provided by the

Atmospheric Environment Service. In contrast to this, 68% of the chill units came from the NW to NE.

Tree Swallows did not show any preference for entrance hole sizes between 3.8 cm and 4.4 cm in diameter, and even used duck nest boxes with entrances 10.5 x 8 cms. However, Bluebirds showed a clear preference for entrances 4.4 cm over smaller ones. Recommended entrance hole sizes for House Wrens range from 2.2 to 3.8 cms. Our tests showed that when given a choice between entrances 2.2 cm and 2.5 cm vs 3.2 cms, all used the 3.2 cms. Wrens also used entrances of up to 4.4 cm in diameter.

Choices of internal dimensions were offered to the birds by pairing boxes 15.3 x 15.3 cms with those into which inserts were built to restrict the floor plan to 10 x 10 cms. Tree Swallows overwhelmingly chose the larger size (22 times vs 6 uses in the smaller). Bluebirds chose the small 10 x 10 cm size nine times and the 15.3 x 15.3 cms three times. There was thus a highly significant difference ($P<0.01$) between Tree Swallows and Bluebirds in their choice of internal dimensions.

House Wrens fill most nest sites with twigs and the volume of the box may be more important to them than internal dimensions. The 10 x 10 cm boxes had a volume of 1935 cm^3 and were used 45 times compared to the 15.3 x 15.3 cm boxes with a volume of 4588 cm^3 which were used eight times. The depth of the box from the bottom of the entrance hole to the floor was tested using boxes 15.3 x 15.3 internal dimensions. The Tree Swallows chose those 12 cm deep 21 times compared to 9 uses in those 16.5 cm deep. Their preference for relatively shallow boxes with large internal dimensions may be because they have legs and feet poorly adapted for hopping and they must use their wings to reach the entrance hole.

Starlings chose duck boxes 33 cm deep exclusively over those 24.5 cm and 18 cm. They also preferred dark boxes painted black inside and where choice was available, would not use those with white interiors. Tree Swallows, however, were indifferent to the interior colour of the box, 23 using the black and 22 the white. A study in Tennessee conducted by Pitts showed that Bluebirds preferred boxes with their interiors painted white. When these preferences are combined it may be possible to develop a box which is optimum for one species and is rejected by competators. For example, Bluebirds can be expected to favour a box with an interior painted white, of small dimensions 10 x 10 cm, a large entrance hole 4.4 cm in diameter, and a depth of 16 cms.

Starlings can be expected to reject boxes admitting much light through a large entrance hole which are painted white inside. Tree Swallows would probably favour boxes with shallow 12 cm depth, and large interior dimensions 15.3 x 15.3 cm over those which are deep and small. House Wrens would prefer small volume boxes (>2000 cm^3), with entrances 3.5 cm in diameter, and painted black inside. Further tests of these designs are being done.

In studies concluded in 1980 we showed that Goldeneyes and Hooded Mergansers, when given a choice, preferred nest boxes with entrances 13 x 10 cm over those 10.5 x 8 cms or 7.5 x 6 cms. Occasionally Goldeneyes used boxes with a missing inspection plate which provided an entrance 21 x 13 cms. In 1980 and 1981, we tested preference for boxes with entrances 13 x 10 cms vs 21 x 13 cms. Goldeneyes did not have a significant choice pattern, but Hooded Mergansers preferred the 13 x 10 cm entrances as did all four Wood Ducks which used the boxes.

In 1984, a choice between boxes with or without nest material in the form of wood shavings was offered. Ten Goldeneyes, four Hooded Mergansers, two Common Mergansers, and two Wood Ducks used the boxes with the nest material, none used those without.

Between 1977 and 1984 we measured preferences for boxes mounted at 3 m, 4.5 m and 6 m on the same tree. Goldeneyes, the only cavity nesting ducks using the Mattagami and Muskego Rivers where this test was conducted, showed a preference for the higher boxes. Three used those at 3 m, nine were in those at 4.5 m and 14 used those at 6 m.

We can recommend that nest boxes for Goldeneyes and Hooded Mergansers should have black painted interiors, entrance holes 13 x 10 cms, a depth of 33 cms from the bottom of the entrance hole to the floor, and some nest material in the form of wood shavings. The boxes should be hung at a convenient height above 3 m. The compass orientation of the box and the species of tree on which it is hung do not matter to the birds.

Goose Production Survey - 1985

Canada Geese of the Mississippi Valley Population

Snow melt in the northern part of the Hudson Bay Lowlands was a few days late and nesting was slightly delayed. East of Winisk unusually heavy rains just before the hatch caused extensive flooding of the coastal area and destroyed a high proportion of nests. The survey flight over this sector found only 2 flocks of geese with goslings, but

many composed entirely of adults. Only a small proportion of the MVP breeds in this area, therefore the effect of this flood should not be overestimated.

The OMNR production survey was done 13 and 15 July, deriving a sample mostly from the tide line and the mouths of rivers. A complimentary survey with little overlap was done by T. Miller and D. Thornburg (Illinois) on the rivers and coastal lakes. Near the Hudson Bay coast 2396 birds were banded and 127 previously banded adults were retrapped. In drives from which all birds in the flock were accounted for, the sample size was 2501 and the ratio was 1.5:1 or 60% immatures.

In the photographic sample of 3251, the age ratio was 1.5:1 or 60% immatures. These samples have been combined in Table 1, with results of the last 5 years for comparison.

Table 1. Mississippi Valley Population Production

Year	Photographs & Drives	Adults	Immatures	Total	Imm:Ad	% Immature
1981	13	213	286	499	1.3:1	57
1982	82	1,123	2,013	3,136	1.8:1	64
1983	25*	1,314	1,995	3,309	1.5:1	60
1984	92*	2,267	5,119	7,386	2.3:1	69
1985	66*	2,322	3,420	5,742	1.5:1	60

* Includes drive trap samples.

The 60% immatures measured in the population in 1985 is slightly below the long term average of 64% (20 years) and is well below the good production achieved in 1984.

Canada Geese of the Tennessee Valley Population

Late snow disappearance delayed the start of nesting on Akimiski Island and much of the southern part of the lowlands. Banding on Akimiski Island went well in 1985 and the target of 3000 birds was exceeded by 666 birds. There were 1511 adults, 2155 goslings, and 340 retraps caught in 17 drives. Orange neck collars were fitted to 1497 adults.

The production survey was done on 12 and 16 July, and yielded an

age ratio of 1.1:1 or 52% immatures. This is the same ratio measured in 15 banding drives in which the ages of all birds were recorded. The two samples have been combined in Table 2.

Table 2. Results of the TVP production survey for the last 5 years.

Year	Photographs & Drives	Adults	Immatures	Total	Imm:Ad	% Immature
1981	20	1,392	1,249	2,641	0.9:1	47
1982	57	1,097	1,616	2,713	1.5:1	60
1983	36*	1,997	1,944	3,941	1.0:1	49
1984	50*	1,862	3,013	4,875	1.6:1	62
1985	88*	3,433	3,750	7,183	1.1:1	52

* Includes drive trap samples.

Production of the TVP in 1985 at 52% immatures was well below the long-term average of 57% (22 years). A fall flight smaller than that of 1984 is expected.

Lesser Snow Geese: Cape Henrietta Maria

The snow goose colony on the Cape was flown on 16 July. A total of 68 photographs yielded a sample of 18,356 snow geese. The age ratio was 1.0:1 or 51% immatures.

When the geese at Cape Henrietta reproduce well the birds are scattered throughout the colony in relatively small flocks 50-300 strong. In a poor production year there are few small flocks and many of 1000 + birds which contain no young. In 1985, there were many large flocks scattered throughout the colony, as well as some productive groups of birds in small flocks. We interpret this to indicate that the same flooding which affected the Canada geese in the area east of Winisk also affected the snow geese in the early part of their incubation period and destroyed a large number of their nests.

While many birds had average production in 1985 (long term average 50%, 22 years) as indicated by the photographic sample, overall production in the colony was probably very poor. Table 3 compares production at Cape Henrietta Maria for the last 5 years.

Table 3. Cape Henrietta Maria Snow Goose Production

Year	Photographs	Adults	Immatures	Total	Imm:Ad	% Immature
1981	76	5,166	4,124	9,290	0.8:1	44
1982	25	3,940	3,264	7,204	0.8:1	45
1983	52	3,024	3,487	6,511	1.2:1	54
1984	42	5,414	5,812	11,226	1.1:1	52
1985	68	9,052	9,304	18,356	1.0:1	51

WHITE-TAILED DEER

Cooperative Deer Study - D. R. Voigt

The Cooperative Deer Study is a large-scale field project being conducted in several areas in Ontario. It arose several years ago as a result of at least three events. Firstly, there were frequent questions and concerns by the field about issues involving supplementary feeding and deer harvest allocation. Secondly, several districts had initiated investigations for local management needs, and thirdly, feasibility studies were possible under Section 38 Special Employment Projects. Throughout the study, Special Employment Projects have been invaluable to investigate specific concerns or projects that were eligible within the overall organization of the Cooperative Deer Study. These projects have been sponsored by the Ontario Federation of Anglers and Hunters, Northern Ontario Tourist Operators, the County of Simcoe, Nottawasaga Valley Conservation Authority, and Maitland Valley Conservation Authority. The Cooperative Deer Study has integrated projects by North Bay District, Huronia District, Wingham District, and Chatham District in concert with studies by the Wildlife Branch.

The specific objectives of the Cooperative Deer Study are listed below.

Supplementary Feeding Objectives

1. Evaluate the design and use of feeders. Four feeder types (hopper, barrel, hardhat and trail) will be compared using data from the following: (i) cost of building feeder, (ii) cost of maintaining, (iii) number of deer using a feeder per unit time, (iv) aggressive interactions per deer using feeder including number of deer prevented from feeding, (v) quantity of feed consumed per deer, and (vi) amount of feed wasted per feeder including consumption by other species.
2. Determine the number of feeders required in an area including the distance between them.
3. Determine the number of deer using a feeder including percentage of herd reached.
4. Determine acceptability by deer of feed rations such as a pelleted total diet and corn/oats. Evaluate cost of these

rations and prepare guidelines for usage based on energy, protein and nutrient requirements of deer.

5. Develop guidelines for a schedule of feeding during the winter based on winter severity index and the capacity of deer yards to maintain a number of deer.

Herd Productivity, Survival and Recruitment Objectives

1. Develop and/or test techniques and parameters to assess the condition of a deer or a deer herd.

2. Develop and/or test techniques that deer managers can use to measure (i) productivity, (ii) recruitment rates, and (iii) rate of increase of a herd.

3. Determine mortality rates and cause of death for deer during all periods of the year.

4. Determine the movements and migration of deer between winter and summer range including the harvest period.

5. Determine the effect on productivity and recruitment of (i) hunting, (ii) weather (winter and summer), (iii) deer behaviour, and (iv) habitat.

6. Develop a comprehensive spatial, stochastic computer simulation model of deer in Ontario. The model would be based on a WMU basis for deer managers and operate using results from this study, literature and local surveys.

Study Areas

Studies in the North Bay District are concentrated in the Loring Deer Yard complex near Arnstein. These studies are divided into yard areas where supplementary feeding occurs with a corn/oats diet, or a total diet pelleted ration, or areas where no supplementary feeding occurs but natural browse has been enhanced by winter cutting programs.

The studies in Huronia District range from yards in the north end of the district near the Severn River in Wood Township where no supplementary feeding occurs, south to major yards at Copelands Forest Management Area where a corn/oats ration is fed, and the Minesing Swamp -Base Borden yard complex where a variety of supplementary feed is given either in the form of a corn/oats ration, a total diet pellet ration, or field corn plots that are left unharvested. In addition, deer are being studied in a smaller yard in a farmland area in the southern portion of

the district where no supplementary feeding occurs.

In the Wingham District, three areas where deer concentrate during the winter are being investigated, one of these being along the Bayfield River and another centered on the Saratoga Swamp.

In the Chatham District studies are concentrated in Rondeau Provincial Park although one of the prime objectives of this study is to follow deer outside of the park. Specific objectives in that study are 1) to define the area outside Rondeau that deer use between their spring exodus from the park and their return in the late fall and early winter, 2) to determine the habitat that deer use after leaving the park, and 3) to determine when deer return to the park each year.

Cooperators and Staffing

A great many people from Districts, Regions, and Main Office of the MNR, as well as universities are assisting in the collection of data for this study. Staff from the Wildlife Branch include Dennis Voigt as Study Leader, Fiona McKay stationed at SRS Maple as a liaison Biologist, Tim Bellhouse as Field Biologist based at the Loring Deer Station, Jim Broadfoot as Field Biologist based in the Huronia District studies, and Peter Smith as Resource Technician. Howard Smith, when he was in charge of the Provincial Deer Management Program, was very involved in the study up until the end of this year. North Bay District staff have been cooperating with the study since its inception: included especially are Roger Wolf, Merilyn Strathearn, Ernie Bain, and Paddy Stillar.

In Huronia District, the studies have been greatly assisted by the Central Region Deer Technician, Wayne Lintack, but support from many of the staff in Huronia District has occurred including extra efforts with Special Employment Projects.

In the Wingham District, District Biologist Mike Malhiot has been overseeing the studies with the assistance of Ken Maronets, Biologist, as well as staff on Special Employment Projects.

In the Chatham District, George Duckworth has been responsible for the development of the study but he has received assistance from Marg Reed, a Fish and Wildlife technician, as well as a group of Rondeau Park staff who have contributed their time and services.

Assistance from outside the Ministry has become an increasingly important part of this study. In addition to the aforementioned

sponsors of Special Employment Projects, several universities are involved with the study. Dr. Josef Hamr is completing a post-doctorate study with Dr. George Bubenik at the University of Guelph. Hamr is specifically looking at condition indices of deer and is attempting to come up with simple measures that field managers may use to determine the status of their deer herd. His work is centered on the use of two indicators of condition, thyroxines T3 and T4. Oswald Schmitz is conducting a Ph.D. on the foraging strategies of deer and how those strategies can help managers determine the energy and feed requirements of deer during different winter circumstances. He is working in concert with Dr. Tom Nudds of the University of Guelph, and Dr. Gary Belovsky of the University of Michigan. Both of these latter studies have been funded by the Ontario Renewable Resources Research Grant fund. Other projects are being proposed both at the University of Guelph and at Laurentian University for Masters students and anticipate that several graduate student projects will be added to the Cooperative Deer Study to help achieve objectives. In addition, we are seeking the cooperation of other experts. For example, Ken Kerr of the Minnesota Department of Natural Resources has analyzed, and is helping in the interpretation of, a sample of blood sera from deer collected in several areas. These sera will help us to interpret other condition indices. The University of Guelph, has through the cooperation of Dr. Ian Barker, assisted in the necropsy of several of the study deer that have died due to unknown causes.

The Cooperative Deer Study is seeking to compare results from several areas within the province. Studies from many different Wildlife Management Units are being integrated but data collection methods and efforts have been standardized. We hope that this comparative approach will allow us to extrapolate results to several other areas. In addition, we hope that the value of several ongoing Regional studies will be even further enhanced because of the Cooperative Deer Study. Examples include the studies on the seasonal distribution and productivity of road-killed deer such as those by Lintack in Huronia District, and the studies on the gross productivity of both harvested and road-killed deer by Midge Strickland in Algonquin Region. Results from studies such as those in the Canonto townships being analyzed by

Hussell will be of considerable value in interpreting results from this study.

Preliminary Results

During this past winter (1985-86) we obtained our second large sample of radio-tagged deer in the Huronia and Loring areas. It marked the initiation of studies in the Chatham District and the first large sample in the Wingham District. It is anticipated that capture of a large sample of free-ranging white-tails in these areas will only be necessary for 1 more year (winter of 1986-87). Investigations after that will be centered on specific movements and habitat use as well as details on feeding behaviour during the winter. It has not been possible to collect information on all aspects of the study concurrently, especially during the winter months, because of the heavy labour and time demands of capturing white-tails.

Capturing Deer

Our success in capturing white-tails has been excellent. However, it cost us considerable time and effort as well as the tribulations of learning and and developing techniques over the past several years. We now have extensive experience in the use of clover traps, tranquilizer darts and rocket nets for capturing deer. In Huronia, Loring, and Wingham, the majority of deer have been captured using clover traps. Although we have experience with corrals and the use of handling boxes attached to clover traps, it now appears that a clover trap constructed of wire mesh or netting material and heavily baited with cedar and/or grain is the most cost-effective method of catching deer in most areas during the winter. A minimum crew of 3 is recommended. Handling of the animal is efficiently and safely done through the use of a restraining net bag placed at the door of the trap which entangles the captured deer as it tries to escape. Tranquilization is then relatively easy and processing and handling can proceed quickly.

The use of rocket nets was tested in Huronia District and found effective in catching groups of 2 or 3 deer at once. However, it does require an open clearing where deer can be consistently attracted to a food supply. The method requires considerable conditioning of the deer to the net and rocket apparatus. The third method we have now had considerable experience with is the darting of deer. We have used darts

which contain a radio transmitter to enable us to track the deer 300 or 400 m before they succumb to the effect of the tranquilizer. However, we have found that that method is unreliable since darts often fall out or radio transmitters quit. The studies at Rondeau this winter in January and February demonstrated the merits of using a smaller dart shot from pistols at close range. Eighteen deer were captured there in over 7 days. The dosage of drug required is over twice that required for intramuscular injection of an immobilant in deer. We determined that adult does could be effectively immobilized with 3.6 ml of a 3-parts ketamine to 1-part rompun mixture (200 mg/ml concentration). Deer were observed after darting to either remain in the vicinity or wander off up to 200 m away. We believe that the darting of deer requires a close-range approach and ideally, deer should be feeding (head down) when shot. Some experience suggest that deer are able to move upon the sound of the pistol or rifle before the dart hits them. Coupled with the small flank target offered by white-tails, darting is recommended only under ideal circumstances. Snow cover is important for tracking and spotting immobilized deer.

Processing and Handling of Deer

To date, 273 different deer have been captured. Total captures including recaptures are 378. Radio collars have been placed on 214 deer, the majority (74%) of which were does. All deer now receive collars that are brown in colour with an identification number visible through binoculars at a distance of 50 m. Last year and again this winter we radio-collared bucks with breakaway collars. Experience last winter (1984-85) showed that a collar with a breakaway rubber insert lasted from 50-120 days before falling off. One collar padded with additional foam for breakaway lasted over 223 days. Consequently, this year all bucks have been collared with a foam and rubber insert breakaway collar and we are hopeful that these collars will last from winter until early fall just prior to the onset of the rut and the neck-swelling of the bucks. Total captures and number of radio-collared deer by study area follows.

	LORING	HURONIA	WINGHAM	CHATHAM	TOTAL
Total Captures	171	162	23	19	375
No. Radio-collared	81	94	18	18	211
Does	63	71	4	18	156
Bucks	18	23	14	0	55

Processing of deer involves tranquilizing all captured deer with a 10-parts ketamine to 1-part rompun mixture (concentration - 200 mg/ml). An average-sized doe would require 2 to 2.4 ml of this mixture. Processing with an efficient crew takes 20-30 minutes/deer. That includes taking a blood sample, monitoring the heart and respiration rates, body temperature, various body measurements including weight, total length, girth, hind foot, ear length and neck circumference, insertion of coloured eartags in each ear, determination of lactation, and custom fitting of a radio neck collar. In addition, each animal receives a long-acting tetracycline antibiotic and Dystosel. Dystosel is a combination of vitamin E and selenium that may be effective in minimizing capture myopathy. Capture myopathy has been a rare event in this study in comparison to several others outside of Ontario. When processing is complete we are now able to reverse the effects of the ketamine and rompun by using a drug, yohimbine, which is administered intravenously into the jugular vein. This drug usually results in deer revival and flagging-off within minutes of administration.

All study areas are using the same handling processing procedure including the same data forms. In fact, all data collections, as part of the Cooperative Deer Study, use standard forms for mortality, observations, captures, and radiotracking to expedite analysis and interpretation of data.

Migration

One of the most interesting aspects of the Cooperative Deer Study to date has been the timing and distance of migration by radio-collared deer. We now suspect that where the majority of deer in Ontario are migratory from winter to summer ranges, onset of spring migration or exodus from the yard is variable both among years and areas. For example, in the spring of 1985, deer in the Huronia yards began

migrating as early as the third week in March but other deer continued to leave the yard throughout April and until the first week in May. In contrast, in Loring, migration did not commence until the middle of April and the last deer had left the yard by the 8th of May. More persistent snow cover in that area followed by some very warm temperatures precipitated a mass exodus. The previous year, in 1984, all radio-tracked deer that migrated had left the yard by the 10th of April. That year, deer in Loring also left much earlier, the earliest on the 11th of March although most left around the beginning of April. Deer from most yards appear to disperse in all directions although deer from some portions of the yard appear to be biased to disperse in certain directions. Distances range from a few kilometers up to 86 km. Only a few deer persisted on their winter range during the summer months. Deer in Huronia migrated shorter straight-line distances than those in Loring. Mean distances in Huronia yards varied from 5 to 13 km whereas mean distances in Loring yards ranged from 16 to 42 km. Duration of dispersal varied from just a few days to several weeks. By mid- to late May most deer were on their summer ranges. It appears that some deer persisted in the vicinity of yards even when snow cover was patchy or fast disappearing. During this spring period extensive feeding on grass areas was recorded in many of the yards. This same behaviour of persisting or staging around the vicinity or outskirts of the yards was observed during the fall months. Deer were more variable in their departure dates from summer ranges to winter yards but upon arrival in the vicinity of yards some deer 'staged' nearby for periods of several weeks before entering the core of the yard. Deer returned to the winter yard as early as the 3rd week in September in 1984 but as late as February 19th in a few cases in the winter of 1985. Generally, the majority of movement back to the winter yard from summer ranges occurs after the hunt in the month of December and appears to be related to heavy snowfall or a period of continuous snow cover. However, it is premature to describe the variables influencing all migration, since during the hunt period some deer are part way from summer ranges to winter ranges, others are in winter ranges and many persist on their summer range.

Last fall, in Wingham, staff followed 1 doe during migration when

she moved 7 km from the summer to winter range in a period of 5 hours. Other deer appear to move towards winter yards in a very slow fashion, often stopping for periods of several weeks before continuing their journey. We now know that deer will winter in one Wildlife Management Unit and summer in another or deer occur during the harvest period in other units from that in which they winter. The other interesting result of the migration studies is that there is considerable variation from year to year and area to area in the duration for which deer are resident in the winter yard. Besides having an obvious effect on the condition of the deer and effect on browse or need for feeding, a variable wintering period suggests that the error in estimating time in the yard as used in pellet group survey calculations may be considerable. Many deer are in the yard far less than the period from leaf fall until pellet surveys commence.

Movements, Activity, and Seasonal Habitat

Deer have not always returned to the same portions of winter yards as used in earlier winters, but does have returned to the same summer ranges in subsequent years.

Staff in each of the study areas attempt to follow the same radio-tracking schedule. We have divided the year into 6 seasons of 2-month duration termed winter, spring, fawning, fawn-rearing, pre-hunt and rut/hunt periods. Last year a group of at least 10 adult does in each area were checked on at a minimum of 16 randomly determined occasions during each period. This is supplemented with continuous 48-hour tracking sessions whenever possible (usually 3/period). Every radio-collared deer is tracked at the end of each month within plus or minus 5 days to determine any change in its status.

During the spring and fall periods additional radio-tracking is required to monitor migration. Much of that is done by aircraft because of the remoteness of the areas used by deer during migration and in some cases during the summer period. During the winter months deer are tracked more intensively in shorter 6-hour periods. A sample of deer is radio-tracked in each of fed and unfed areas to compare movement rates, home range size, and use of habitat.

Habitat was surveyed in 1985 for intensively monitored adult does. The forest composition, land-use, crown closure, and presence of fields,

crops, etc. were tallied for each ha within the home range of does. During the winter months a 1 km^2 area within each doe's range is sampled for tracks and trails of deer as a index to the presence and activity of deer. We are also tallying the presence of other access routes of deer such as snowmobile trails and roads. A more detailed assessment of habitat during the winter months will be possible using this same sampling scheme. We have found that the area traversed by deer during both winter and summer months is similar in size - 1-2 km^2.

This past summer we were also able to make some measurements of the accuracy of our telemetry system under a variety of field conditions and using various staff with different levels of experience. Generally, it appears that locations of deer determined from distances of 1.5 km or less are accurate enough for analysis of home range and movements. However, accuracy required for detailed habitat determination is probably not possible without a very intensive, close monitoring of deer.

This past summer we also made some additional effort to capture fawns during the peak of the fawning period. As suggested from the previous summer's experience, the capture of fawns in northern wooded areas is extremely time-consuming and labour-intensive. We do not recommend that this effort be continued.

Mortality Rates and Causes

The use of radio-collared deer allows us to determine the rates and causes of deer mortality in a variety of areas in Ontario. At present, this sample comprises mostly does but a sample of bucks is accumulating, at least for the winter through until early fall period. Radio-tagged animals whose radios are functioning, allow us to determine causes of death other than those likely to be reported through human activities such as hunting and road-kills.

To date, we have not analyzed the mortality rates of does by season because of sample size, but some generalities can be stated. Deer in the Huronia area seem to die at a higher rate due to a greater variety of causes than those in Loring.

In Huronia, in the first year of sampling, half of the adult does died between one winter and the next when the only mortality that occurred in Loring radio-collared does was due to the annual hunt.

However, last year we experienced deer dying of starvation in both areas and cases of predation, poaching, road-kills, and wounding losses are now recorded. The following table shows the causes of death of radio-collared deer in each of the Loring and Huronia study areas since the onset of the study. Samples for Wingham and Chatham Districts are not included.

	HURONIA DOES	LORING DOES
Hunt	4	6
Road-kills	3	1
Poaching	2	1
Wounding	2	0
Dog predation	2	0
Coyote predation	3	0
Wolf predation	0	2
Rabies	1	0
Other disease	1	0
Starvation	3	4
Other	2	2
Unknown	2	1

Analysis of these and similar data in the future will involve investigations of the seasonal changes in mortality rates by age class (fawn, yearling, adult), by location of summer range, relationship to migration, type of habitat, and condition of deer at time of capture and at time of death. A knowledge of mortality rates and causes will be fundamental to increase our understanding of the population dynamics of deer and improve the predictability of modelling exercises as well as the determination of quotas in the selective harvest areas and the controlled hunts.

Feeder Types, Consumption Rates, and Acceptability Rates

A major part of the Cooperative Deer Study is an investigation of the how, why, when, and where of supplementary feeding of deer. The studies on condition will help us understand the benefits of feeding deer but many other variables also impinge on deer condition. Among the more practical information on feeding deer which we hope to derive are estimates of the relative merits of feeder types, consumption rates of supplementary feed by deer, acceptability of different rations, and the

number of deer serviced by various types of feeding operations.

Four types of feeding are being compared - hopper feeding, the pail-hardhat system, 50-gallon barrels, and trail feeding. These are being compared with respect to initial cost, cost of maintenance in terms of machines, number and time of staff. Estimates of the number of deer being serviced by different types of feeders are as important as consumption rates per feeder. We are also aware that some areas may require a feeding program to supplement the non-availability of sufficient browse and these programs may be longer than emergency-feeding programs which would be necessary only during severe winters. For the latter situations we are comparing the consumption rate and acceptability of rations like corn/oats and total-diet pellets placed in a trail-feeding system. For permanently established feeders such as hoppers we have conducted intensive observations of deer to observe the time spent feeding at these sites, the consumption rate/deer, the number of deer visiting a site that do not feed, and a measure of the social interaction, especially agression, that occurs at the site. Our experiences suggest that relatively few deer can feed at one hopper at the same time and it may be several hours before a group of deer are all able to feed. Despite that, consumption rates at hoppers can be very high, especially in the late winter period.

Many of the studies on the effect of feeding began in 1985 and we are hopeful that they can continue after next year when there will be less emphasis on the trapping and capture of deer. Some of these studies will require automatic monitoring at feeders and activity counters to determine the schedule of deer use of feeding. The studies by Schmitz on the foraging strategies of deer will provide us with more indication of the interplay between natural browse consumption, cropping rates, and availability and its importance in assessing the need to feed deer. Similarly, the studies by Hamr which monitor the condition of deer during the winter period will be important in helping us measure and understand indicators of the need to feed white-tails. The latter study has been supplied with a large sample of deer sera but results are still preliminary. We have observed, however, that large adult bucks are, in many areas, in very poor condition during our winter months. It appears that after the rut they have insufficient time to build up fat

reserves and consequently, by mid-winter, are in very poor condition. Similarly, many fawns are in poor condition by late winter and in the winter of 1985-86, we are seeing more evidence of this than in earlier winters.

More details on the Cooperative Deer Study are available through the Wildlife Branch. For information on a slide presentation on the Cooperative Deer Study, contact Dennis Voigt.

Analysis of the Canonto Deer Study Data: Effects of Hunting Mortality, Winter Severity and Population Density on Future Population Levels - David J.T. Hussell

This report updates the results of the analysis of the Canonto white-tailed deer population given in last year's report. Therein I provided support for the basis for the selective harvest system by showing that doe hunting mortality had a negative effect on future population levels in the Canonto Study Area in the period 1955-79.

In this report I extend the analysis to include the period of the selective harvest (1980-1984) and I demonstrate additional effects on changes in population size of winter severity and population density.

The objectives of the Canonto study, as summarized previously, are as follows:

(1) To determine levels and trends in population and harvest.

(2) To assess effects of hunting effort, day of the hunt, and weather on the kill.

(3) To determine the role of hunting in mortality and its effect on population levels.

(4) To examine the relationships between herd levels and environmental conditions.

(5) To relate the results of this intensive study to ways in which data available to managers may be used for management purposes.

In previous reports I gave results that bear on objectives (1), (2) and (3). The results reported here relate primarily to objectives (3) and (4), and we can begin to see how they may be related to management questions (objective 5), particularly the setting of antlerless tag quotas. First, I demonstrate that an index of buck population provides an adequate representation of population trends. Secondly, I examine

Table 1. Population levels, doe hunting mortality and winter severity in the Canonto Study Area, 1954-84.

Year N	Population Index [a] P_N	P_{N+2}	Doe Hunting Mortality [b] D_N	Winter Severity [c] S_N
1954	2.99	1.49	41.3	30
1955	1.70	1.65	29.4	6
1956	1.49	1.95	16.5	0
1957	1.65	2.25	11.6	16
1958	1.95	2.48	15.5	20
1959	2.25	2.61	14.1	28
1960	2.48	2.63	23.2	0
1961	2.61	2.59	27.3	2
1962	2.63	2.52	40.9	7
1963	2.59	2.44	29.1	0
1964	2.52	2.38	31.8	0
1965	2.44	2.32	40.0	1
1966	2.38	2.26	28.6	4
1967	2.32	2.18	30.5	0
1968	2.26	2.07	25.9	18
1969	2.18	1.92	19.1	13
1970	2.07	1.73	35.0	37
1971	1.92	1.51	35.0	21
1972	1.73	1.27	19.8	16
1973	1.51	1.05	20.9	11
1974	1.27	0.85	15.0	9
1975	1.05	0.70	18.2	13
1976	0.85	0.61	12.2	11
1977	0.70	0.60	9.1	45
1978	0.61	0.67	12.2	31
1979	0.60	0.86	10.0	0
1980	0.67	1.22	2.6	18
1981	0.86	1.83	1.7	5
1982	1.22	2.85	3.0	0
1983	1.83	-	3.5	39
1984	2.85	-	10.9	0

[a] Bucks killed/100 km^2-day taken from the curve in Figure 1. P_N = value for year N, P_{N+2} = value two years later.

[b] Doe hunting mortality D_N is the actual number of does killed/100 km^2 during the entire hunting season in year N.

[c] Winter Severity Index (S_N) for the winter following year N at Dacre (20 km north of the study area). The annual index is the sum of weekly averages of 10 stations assigned weekly values as follows:

Depth of snow (cm)	No crust	Crust
0 - 38.0	0	1
38.1 - 50.7	1	2
50.8 - 76.2	2	3
> 76.2	3	3

the effects of doe harvest, winter severity, and population size on trends in the population index. Thirdly, I show how this information can be used to adjust doe harvest in accordance with management objectives for future populations.

Because the kill of does and fawns is restricted, a population index based on total kill per unit effort is not appropriate when a selective harvest is in effect. However, an index based on the buck kill is likely to be reasonably consistent across different harvesting regimes. Moreover, our main interest is in the behaviour of the buck segment of the population, in the sense that as managers we seek to effect changes in the buck harvest by manipulating the antlerless kill.

A multiple regression analysis, similar to that described in the 1983 annual report, was undertaken to detect effects of year, day of the hunt, weather and man-days of effort, on bucks killed per 100 km^2-day. The resulting trend in the population for 1954-84 is shown in Figure 1. The annual buck indices for 1955-79, taken from the curve in Figure 1, are very highly correlated with the total population indices which were given in Table 1 in the 1984 report ($r = 0.905$) indicating that the buck index is a very good indicator of total population level in this period. The main features of the trends in the buck index are a steep decline from an initially high level in 1954 to a trough in 1955-56, a rapid return to relatively high levels in 1961, a slow decline in the 60s followed by a more rapid decrease to very low levels in the late 70s, and finally, following introduction of the selective harvest, a spectacular increase to high levels in 1984 that were comparable to those of 1954 and 1961-62.

Our next task is to try to identify the factors that were operating on the population to induce the changes seen in Figure 1. Using a similar approach to that in the 1984 report, the first step is to build a model, in the form of an equation, that includes the effects that we think may be important. Once we have a plausible equation, we can then use the real data from Canonto to see whether the effects that we have postulated can be detected in the Canonto population.

One of the most important factors affecting population changes from one year to the next will be the size of the initial population. In our case the initial population is represented by P_N, the buck population

index in year N. In addition, the change in the buck population between year N and year N+2 (two years later) is likely to be affected by the number of reproductive does in the population in year N (since fawns produced by these does in year N+1 will be recruited into the buck population as yearlings in year N+2). Thus a simple model of population change in relation to current population and doe harvest may be represented as:

$$P_{N+2} - P_N = a + bP_N + cD_N \quad (1)$$

where P_N and P_{N+2} are the buck population indices in years N and N+2 respectively, and D_N is total doe kill (not an index) from the study area in year N. Equation (1) can be rearranged as follows:

$$P_{N+2} = a + (1+b)P_N + cD_N \quad (2)$$

In equation (2), b is expected to be positive, unless the population is at or above carrying capacity and c is expected to be negative since removal of reproductive does is likely to reduce the potential for future population increase.

Mention of the carrying capacity points out that the model in Equation (2) is an incomplete representation of the real world. Population increase usually follows a sigmoid relationship, rather than the linear one represented by equation (2). In other words, the rate of population increase is not constant, but tends to be rapid when the population is low, then slows as the population becomes larger, and finally reaches zero when the population is at the so-called "carrying capacity". This effect can be represented in the model by adding another term to the equation:

$$P_{N+2} = a + (1+b)P_N + cD_N + dP_N^2 \quad (3)$$

The P_N^2 term in equation (3) represents a density dependent effect. Its coefficient, d, is expected to be negative, and therefore its effect is to dampen the positive effects of $(1+b)P_N$ as P_N increases until at carrying capacity bP_N is equal to $-dP_N^2$ and population change depends

only on the doe kill D_N.

However, there is another refinement that should also be considered. We would expect the same doe kill to have a larger negative impact on the population when the population is low than when it is at or near carrying capacity. The reason for this is that when the population is at carrying capacity the net gain in population is zero, regardless of the number of does present. What this means is that the productivity associated with those does is then exactly balanced by natural mortality. Therefore removal of some of those does will have a relatively small effect on population change compared with the situation at low population levels, because with the population near carrying capacity there will be a compensating increase in productivity of the surviving does or a decrease in mortality, both of which will tend to keep the population at or near carrying capacity. This is also a density dependent effect and it can be represented in the equation by adding a term in $D_N x P_N$, since P_N represents the population level and D_N is the number of does killed. Its coefficient, e, is expected to be positive as it acts at high population levels to compensate for the negative effects of doe kill, represented by cD_N in equation (3). With this addition the equation becomes:

$$P_{N+2} = a + (1+b)P_N + cD_N + dP_N^2 + e(D_N x P_N) \qquad (4)$$

So far we have not considered the effects of severe winters on population change. The exact way in which winter severity acts on deer populations is a controversial topic. For the present purposes, let us suppose that it is possible to devise a severity index that is meaningful in the sense that it represents environmental conditions that have a direct negative effect on deer populations. For the winter following the hunting season in year N, we will call the severity index S_N, with S_N increasing as winters become more severe. While the winter severity in year N+1 may also affect the buck population in year N+2, the effect of the winter in year N is likely to be greater because it can act directly both on the production of fawns and on the survival of yearlings, which are due to enter the buck population in years N+2 and N+1, respectively. Thus, I will ignore the potential effects of winter

severity in year N+1 and consider only the effects of S_N.

Opinions vary as to whether winter severity acts as a density dependent or density independent effect on populations of white-tailed deer. I will not attempt to address that issue here, but will simply assume that the effect is density dependent. This assumption means that a greater proportion of the population suffers mortality related to the severity of the winter if the population is large than if it is small. Inçluding winter severity, our model is represented now by the following equation:

$$P_{N+2} = a + (1+b)P_N + cD_N + dP_N^2 + e(D_N x P_N) + f(P_N^2 x S_N) \quad (5)$$

The coefficient f in this equation is expected to be negative and at high populations it acts to increase the negative impact on future populations represented by the coefficient d. In effect, this means that the carrying capacity is decreased in severe winters.

Now we come to the second step in the analysis, which is to attempt to show whether or not the terms in equation (5) can in fact be used to describe the changes in populations recorded in the Canonto Study Area. The values of P_{N+2}, P_N, D_N and S_N for 1954-84 that I used in this analysis, are given in Table 1. They were used in a multiple regression analysis to estimate the values of coefficients a, b, c, d, e, and f in equation (5). The result was as follows:

$$P_{N+2} = -0.001 + \underset{***}{2.98}P_N - \underset{***}{0.13}D_N - \underset{**}{0.72}P_N^2 + \underset{**}{0.045}(P_N x D_N) - \underset{*}{0.003}(P_N^2 x S_N) \quad (6)$$

One, two and three asterisks indicate coefficients that are significantly different from zero at $P<0.05$, $P<0.01$ and $P<0.001$, respectively. This means that all of the factors postulated to have effects on future population, when considered simultaneously in the multiple regression, did in fact have demonstrable effects in the Canonto deer herd in 1954-84 period. Moreover the direction (positive or negative) of each effect was as predicted by theory. The implications of equation (6) are more easily understood if it is converted to graphical form.

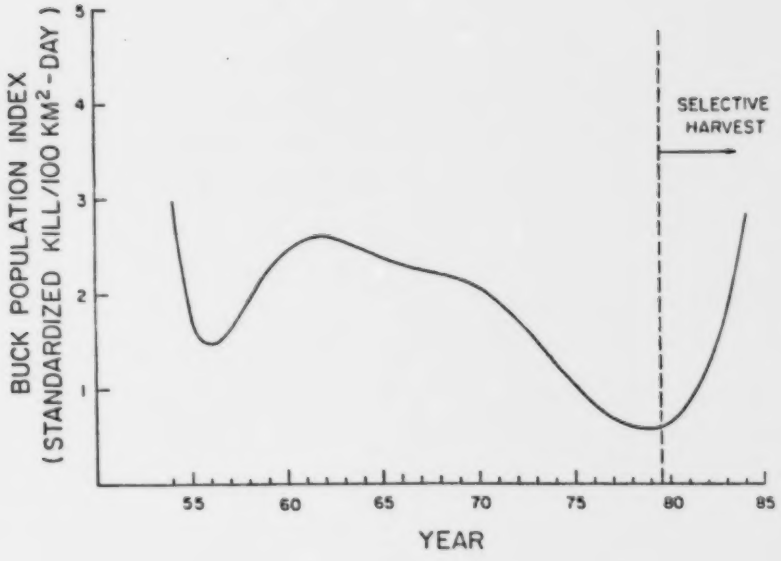


Figure 1. Buck population index, Canonto Study Area, 1954-84. The index is expressed as bucks killed/100 km^2 on one day of the hunt, standardized for day of the season, hunting effort and weather.

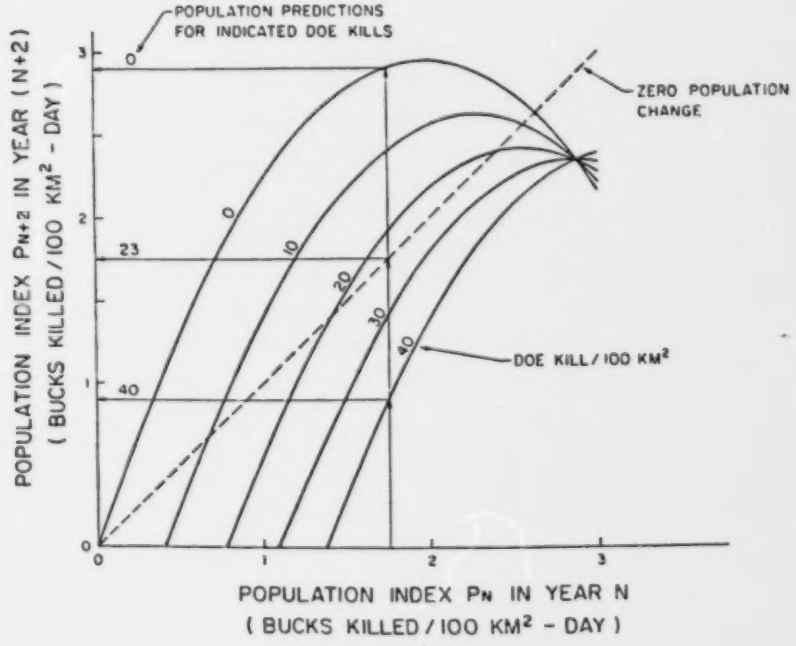

POPULATION PREDICTIONS FOR INDICATED DOE KILLS
ZERO POPULATION CHANGE
DOE KILL / 100 KM²
POPULATION INDEX PN+2 IN YEAR (N+2)
(BUCKS KILLED / 100 KM² - DAY)
POPULATION INDEX PN IN YEAR N
(BUCKS KILLED / 100 KM² - DAY)

Figure 2. Effects of doe hunting kill on buck population two years later in the Canonto Study Area, 1954-84. The curved lines show predicted buck indices in year N+2 (vertical axis) corresponding to the buck index in year N (horizontal axis) for several levels of doe kill (0, 10, 20, 30, 40 per 100 km^2).

The relationship between the buck population index P_N in any year (year N) and that two years later (year N+2), assuming several different levels of doe hunting mortality and the median value of winter severity (S_N=11) is shown in Figure 2. For example, if this year's buck population index is 1.75 bucks killed/100 km^2-day, find this figure on the horizontal axis and follow it vertically to intersect the lines representing doe kill/100 km^2. The intersection points indicate the prediction of the buck population index for the year after next. Thus on average, if the doe kill is zero, the buck population index 2 years hence should increase to about 2.9; and if the doe kill is 40 per 100 km^2, the buck index is expected to decrease to about 0.9. To maintain the same population level (1.75), the doe kill should be about 23 per 100 km^2. The diagonal dashed line in Figure 2 represents points with no population change. By following this line from the bottom left to the top right, we see that the doe kill for no change in population increases steadily from zero to about 24 as the buck population index increases from zero to 2.0, and then declines rapidly again to zero when the buck population is at 2.63. This means that under average winter conditions, the maximum number of does that could be taken without a subsequent decline in population was 24 per 100 km^2, and this occurred at a buck population index of about 2.0. Moreover, when the buck population index increased above 2.63 a subsequent decline became inevitable, no matter how few does were removed. This implies that the population was then above carrying capacity and it would tend to fluctuate about the carrying capacity.

Another enlightening aspect of the graph in Figure 2 is that at the highest population levels the "doe kill" lines converge and form a single point at a buck population index of 2.9/100 km^2-day for the current year. At this population level a decline to about 2.3/100 km^2-day in two years is predicted regardless of the doe kill. This implies compensatory mortality (or failure to reproduce among surviving does) when no does are harvested as compared with the situation when there is a high harvest. Consequently, the size of the doe harvest has relatively little impact on future populations when the population is near carrying capacity. On the other hand, at low and moderate population levels the number of does killed has a very substantial

impact and compensatory mortality is then negligible.

Figure 2 represents the situation under average winter conditions. What difference does it make if it is an exceptionally mild or an exceptionally severe winter? Figure 3 shows similar sets of curves for very mild (S_N=0) and very severe (S_N=45) winters, representing the extreme values in our data. The main effect that we see here, is a reduction in population levels two years after a severe winter, especially when the initial population is high. In addition, the maximum number of does that can be killed with no subsequent decrease in population increases to about 29/100 km^2 if the following winter is mild and decreases to about 17 if it is severe. Moreover, the equilibrium point if no does are harvested is at a buck index of 2.75 in a mild winter and at about 2.30 in a severe winter indicating that carrying capacity is effectively reduced in severe winters.

It is interesting to examine the relative effects on the population of winter severity and doe harvest. Basically, the size of the doe kill has a big impact on population when populations are low and little impact when the population is high. When the buck population index reaches 2.9, the effect of varying the doe kill is zero, regardless of winter severity. On the other hand, winter severity has the greatest impact when the population is high. At a population of 2.9, the predicted population two years later varies from about 1.5 to 2.6, depending only on whether the winter is severe or mild. On the other hand, if we move down to a buck population index of 2.0, we see that the potential for manipulating the population by changing the doe kill is already quite large, and the effect of winter severity is considerably reduced. For doe kills varying from 0-40/100 km^2, at an initial population of 2.0, the predicted future population varies from 1.5 to 3.1 following mild winters and from 1.0 to 2.5 following severe winters, indicating a potential impact of about 1.5 index points due to doe kill but only 0.5 index points due to winter severity.

In Figure 5 of the 1984 annual report, I graphed doe kills in the Canonto Study Area in 1955-79 and provided an assessment of what the doe kills should have been to return total deer population index to 6.0 deer killed/100 km^2-day. My conclusion was that, to achieve that goal, doe kills were excessive in 1956 and 1957 and in most years after 1969. In

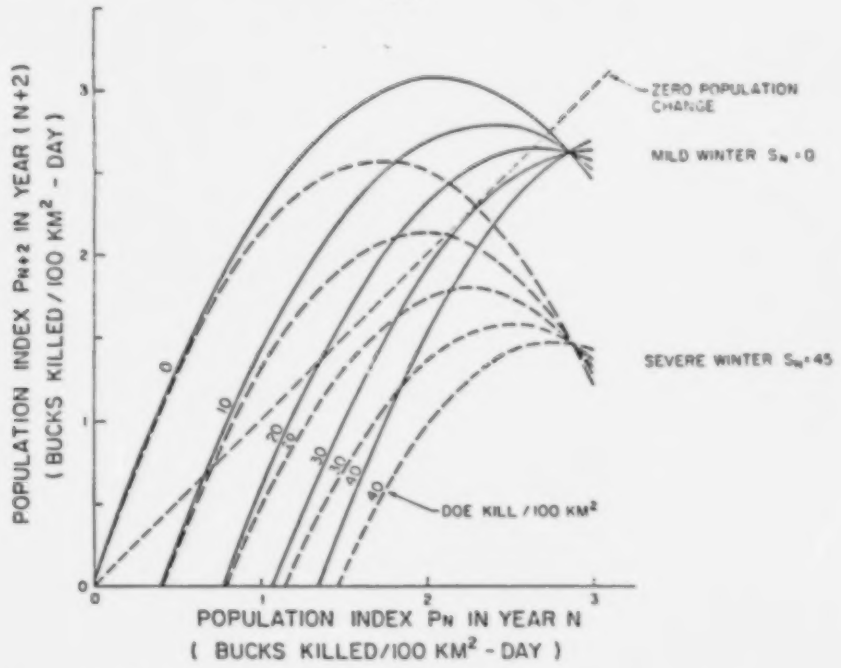

POPULATION INDEX P_{N+2} IN YEAR (N+2)
(BUCKS KILLED / 100 KM² - DAY)
ZERO POPULATION CHANGE
MILD WINTER S_N = 0
SEVERE WINTER S_N = 45
DOE KILL / 100 KM²
POPULATION INDEX P_N IN YEAR N
(BUCKS KILLED/100 KM² - DAY)

Figure 3. Effects of mild and severe winters on the relationship between doe hunting kill and buck population index in the Canonto Study Area, 1954-84. The upper group of curves (solid lines) are for mild winters (S_N=0); the lower group (broken lines) are for severe winters (S_N=45). See Figure 2 for further explanation.

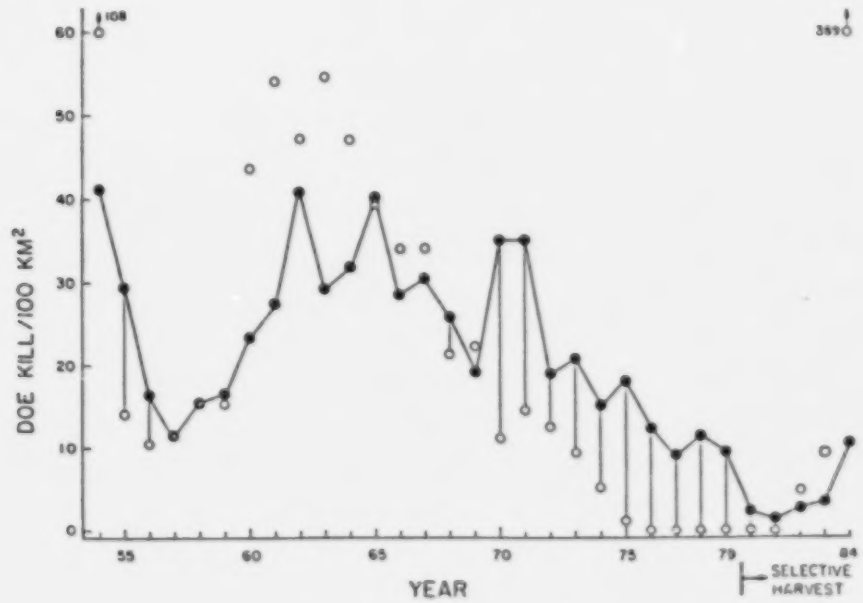


Figure 4. Doe hunting kill, Canonto Study Area, 1954-84. Solid circles and the continuous lines indicate hunting mortality of does. Open circles indicate calculated doe kill for maintaining a buck population index of 2.2 (see text). Vertical lines show excess of actual doe harvest over calculated harvest.

the remainder of this report I will update that analysis, using the results described above and covering the years 1954-84, thus providing an assessment of the appropriateness of measures adopted since the introduction of selective harvest.

First, I will assume that our objective is to maintain a buck population index of 2.2, as regression analysis shows that this represents the same target level as the 6.0 index value of the previous analysis. Note that at this level the population will remain stable in average winters if the doe kill is about 23/100 km^2.

Doe kills in the years 1954-84 are shown in Figure 4, together with the doe kill that would have returned the buck population index to 2.2 as rapidly as possible, according to the regression results described earlier. To achieve this objective, it appears that doe kills were somewhat excessive in 1955 and 1956 and were consistently larger than they should have been from 1970 to 1979.

In 1957-59 and 1965-69, doe kills were approximately in accordance with proper levels. In 1954, 1960-64, and 1984, the buck population index was at high levels (greater than 2.4) and higher doe kills than occurred would not have reduced future populations below the target level. During these years, and particularly in 1954 and 1984, the population was at such a high level that the size of the doe kill would have had very little effect on future populations and therefore could have been increased without fear of serious repercussions.

The decline of the population in the 1970s appears to have been induced initially by two years of high doe kills in 1970 and 1971, each of which was followed by a severe winter. This was followed by a series of years of excessive doe kills and by 1976 the population had declined to a level at which zero doe kill would not have immediately returned the buck index to the 2.2 level. That the winters in the 1970s were generally more severe than in the 1960s only compounded the problem. However, according to the predictions of the regression analysis, a 50% reduction of doe kill to about 10 per 100 km^2 from the approximately 20 per 100 km^2 that occurred in 1972 or 1973 would have been sufficient to restore the population to the desired level.

Doe kills during the first four years of the selective harvest were clearly appropriate to achieving the object of increasing the population

quickly, but by 1983 they were already considerably lower than was necesssary to achieve a buck index of 2.2 by 1985. By 1984 the buck index had reached 2.85, and the regression results indicate that it was likely to decline slightly by 1986 (see below), regardless of the doe kill. Thus our results indicate that a doe harvest of 30-40 per 100 km^2 in 1984 instead of the actual kill of only 11 does per 100 km^2 would not have had a significant negative impact on the population.

The last year used in the regression analysis was 1982 (Table 1), because P_{N+2} was not yet available for later years. However, by inserting the values of buck index, doe kill and winter severity for 1983 and 1984 in equation (6), we can predict the values of the buck index, P_{N+2}, for 1985 and 1986, respectively. When that is done the predicted buck index for 1985 is 2.48 and that for 1986 is 2.64. Thus our best prediction is that there will be a slight decline in the buck population index from the level of 2.85 attained in 1984.

A few words of caution should be added here about these results. The regression analysis describes what happened to the Canonto deer population in the last 30 years. It will be a useful aid in predicting what will happen in the future only if the population behaves in the same way as in the past. We cannot be certain that this will be so. Although the model has been designed to represent a plausible set of cause and effect relationships, the results represent correlations among variables that may or may not be due to cause and effect. Therefore, there is a possibility that the analysis describes spurious or chance relationships that are meaningless. Nevertheless, the results agree qualitatively with our expectations and give us confidence that we are describing the postulated cause and effect relationships of the model. Thus our approach to future results should be to use them to test the current version of the model and to learn more about additional factors that may affect the dynamics of the population, but which may not have been considered in this model. Moreover, a satisfactory test of the model will be achieved more quickly if anterless quotas are manipulated experimentally with that objective in view than if the quotas are determined according to other management objectives.

Finally, how can these results be applied to determine antlerless tag quotas in other wildlife management units? In principle, other data

on kill per unit effort, doe kill and winter severity can be treated in the same manner. Data from provincial mail surveys and other sources may prove to be suitable if they have been collected in a standard fashion for a long enough series of years. In future reports, I hope to have more to say on the application of these ideas and results to practical management problems.

Canonto Deer Hunt - P.C. Smith

During the open season of 1985, deer hunting activities and harvest were monitored in the Canonto Study Area (CSA). Data concerning age, sex, physical characteristics, group sizes and composition, and location of the harvested deer were collected.

For the 1985 season, 788 hunters spent 3,140 man-days of hunting during which time 631 observations of deer were made; 139 deer were shot, 369 deer were seen but not shot at, 104 deer were shot at and missed, and 17 deer were wounded and escaped (Tables 1 and 2). Two additional wounded deer were found dead and included in the kill. Two bears were shot and 23 other bears were observed. Two sightings of moose were reported during the deer hunt.

Rain and snow dominated the 1985 deer season and produced the worst hunting conditions since the study began. Despite the gloomy weather, the first week of the hunt was surprisingly good. The number of men and harvest remained about the same as last year, while hunting effort and sightings decreased by 11% and 13% respectively. Interviews with hunters confirmed that actual hunting effort was much lower than recorded. Hunters saw deer at a rate of 1 per 5 man-days and shot 1 deer for every 22 man-days effort. The extension of the deer season to two weeks provided increased hunting opportunities for 284 men. This group, 186 men (previously checked) plus an additional 97 men, shot 25 (18%) deer and made 83 (13%) sightings.

Age and sex of deer harvested on the CSA during the 1985 season are shown in Table 3. Fawns and yearlings of both sexes, comprised 52% of the total kill and yearling bucks accounted for 25% of the harvest.

TABLE 1. Summary of 1985 hunt for Canonto Study Area.

Group	Men	Antlerless permits	Kill	Total obs*	Effort (man-days)
North & South Combined					
77 hunt camps	661	128	131	540	2815.5
15 tent camps	58	5	6	73	260.5
25 casual groups	69	2	2	18	64.5
Total	788	135**	139	631	3140.5
Northern Half					
41 hunt camps	343	69	73	287	1402.5
8 tent camps	30	4	4	36	159.5
19 casual groups	47	1	1	6	32.5
Total	420	74	78	329	1594.5
Southern Half					
36 hunt camps	318	59	58	253	1413
7 tent camps	28	1	2	37	101
6 casual groups	22	1	1	12	32
Total	368	61	61	302	1546

* Including kill
** 1000 issued for entire WMU # 63.

In 1985, 1000 antlerless permits were allotted for WMU #63 and hunters from the study area accounted for 13% of the Unit total. The CSA represents about 7% of the land area of Wildlife Management Unit (WMU) #63. There were 135 deer hunters from the CSA with antlerless permits and over three quarters of the hunt camps had one or more permits. From 1980 to 1985, the ratio of applications for antlerless permits dropped from 1 permit/42 men to 1 permit/4 men. In 1985, 46% of the CSA hunters with antlerless permits were successful (Table 4).

TABLE 2. Daily effort and observations for Canonto study area - 1985.

First Week	Mon Nov 4	Tues Nov 5	Wed Nov 6	Thurs Nov 7	Fri Nov 8	Sat Nov 9	Total
Man-days effort	403	533	382	479.5	482	263.5	2543
No. men	544	583	515	555	544	373	-
Bucks killed	12	20	7	8	14	8	69
Does killed	4	10	3	4	2	1	24
Fawns killed	2	7	2	5	4	1	21
No. seen but not shot at	66	88	33	55	43	13	298
No. deer missed	20	23	12	14	14	7	90
No. wounded which escaped	2	6	2	3	2	1	16*

Second Week	Sun Nov 10	Mon Nov 11	Tues Nov 12	Wed Nov 13	Thurs Nov 14	Fri Nov 15	Sat Nov 16	Total
Man-days effort	16	113.5	101.5	73.5	81	126	86	597.5
No. men	23	136	127	91	104	143	118	-
Bucks killed	-	2	1	1	-	2	2	8
Does killed	1	4	1	-	1	3	1	11
Fawns killed	-	2	1	-	-	1	2	6
No. seen but not shot at	1	19	14	5	10	8	16	73
No. deer missed	-	2	-	1	4	2	5	14
No. wounded which escaped	-	-	-	-	-	-	1	1

* Two additional wounded deer were found dead and included in the kill.

TABLE 3. Age of deer harvested on CSA during 1985 season.

Age*	Male	Female	Both sexes
Fawn	18	9	27
1 1/2	35	11	46
2 1/2	11	9	20
3 1/2	15	2	17
4 1/2	6	5	11
5 1/2	3	1	4
6 1/2	1	1	2
7 1/2	1	1	2
8-10	-	1	1
Unaged adult	5	4	9
Total	95	44	139

* Based on tooth replacement and wear.

TABLE 4. Comparison of antlerless permits and harvest on WMU # 63 and CSA, 1980 - 1985.

	WMU # 63 Area (3181 km^2)						CSA Area (230 km^2)					
Year	80	81	82	83	84	85**	80	81	82	83	84	85**
Total antlerless permits	75	100	125	245	500	1000	20	17	22	41	64	135
Antlerless harvest*	39	52	48	138	224	385	7	5	8	16	36	62
Percent total kill (%)	33	22	23	30	38	41	22	14	28	21	32	45
Successful permits (%)	52	52	38	56	44	38	35	29	36	39	56	46

* Antlerless Harvest = Does plus fawns of both sexes.
** Two week season

Increased sightings were anticipated with the selective harvest system. Antlerless deer were not legal game for many hunters, but these deer were seen repeatedly. Many hunters didn't shoot because they couldn't positively identify the deer. Since 1980, a major shift

occurred between categories of "deer seen but not shot at" and "deer shot at and missed" (Table 5).

In 1980, the number of deer "seen but not shot at" increased dramatically from the previous year, and represented about 76% of the total deer encountered during the hunt. The number of "deer seen but not shot at" increased by a further 6% in 1981. In 1982, the total number of observations was much lower than expected, but this was due to less hunting effort because of poor weather. Better hunting conditions in 1983 plus an expanding deer herd combined to increase the total sightings from the previous year. In 1984, the total number of sightings (722) surpassed the old record of 680 observations which was made during the first week of the 1965 "any deer" season. In 1985, a total of 631 sightings were made during the two week season. This represented a reduction of 13% from the previous year and reflected the

TABLE 5. Comparison of observations on CSA from 1979 to 1985.

	Any Deer Season	Selective Deer Harvest					
Type of observation	1979 %	1980 %	1981 %	1982 %	1983 %	1984 %	1985 % **
Shot	27(79)*	10(32)	7(35)	8(28)	14(76)	16(113)	22(139)
Seen but not shot at	33(97)	76(256)	82(391)	83(276)	72(397)	70(510)	59(371)
Shot at and missed	37(109)	13(42)	8(40)	8(25)	12(66)	12(86)	16(104)
Wounded and escaped	3(9)	1(5)	2(11)	1(3)	2(11)	2(13)	3(17)
Total # deer encountered	100(294)	100(335)	99(477)	100(332)	100(550)	100(722)	100(631)

* Actual numbers in parenthesis.
** Two week season.

poor hunting conditions and subsequent reduction in hunting effort. When the results were compared with observations from the first week, the number of sightings (518) represented 28% fewer observations than made in 1984. Hunters were asked to classify all sightings into four

categories: buck, doe, fawn, or unknown. A summary of identification of sightings is shown in Table 6.

Deer in groups accounted for 30% of the observations made on the CSA during 1985. Reports on groups of deer decreased from 113 to 80 and involved 40% fewer deer than recorded during the previous hunt, as indicated in Table 7.

Hunting with dogs has been a controversial issue in many parts of the province. For the past few years, a concerted effort has been made to better understand the role of dogs on the CSA. As in previous years, organized hunt camps used dogs more often than tent camps and casual hunters (Table 8). Hunters with dogs accounted for 57% of the total hunting effort but only 33% of the observations (Table 9). Dogs were involved with 25% of the multiple sightings on the CSA during 1985. Hunters using dogs observed deer every 9.0 man-days and killed a deer every 38.8 man-days. Hunters without dogs observed deer at a rate of 1 per 3.3 man-days and shot 1 deer for every 14.6 days of hunting. Daily observations and hunting effort with/without dogs on CSA during the 1985 hunt hunt is shown in Table 10.

TABLE 6. Identification of sightings for CSA during 1985 hunt.

First Week		Mon 4	Tues 5	Wed 6	Thurs 7	Fri 8	Sat 9	Total
Killed	Buck	12	20	7	8	14	8	69
	Doe	4	10	3	4	2	1	24
	Fawn	2	7	2	5	4	1	21
Seen	Buck	9	11	5	3	3	-	31
	Doe	31	44	12	22	20	5	134
	Fawn	8	10	3	7	4	-	32
	Unknown	14	17	11	21	16	6	85
Missed	Buck	15	18	7	6	14	6	66
	Doe	5	3	-	4	-	1	13
	Fawn	-	1	1	-	-	-	2
	Unknown	-	1	2	2	-	-	5
Wounded	Buck	2	4	2	1	2	1	12
	Doe	-	2	1	2	-	-	5
	Fawn	-	-	-	-	-	-	-
	Unknown	-	-	-	-	-	-	-
Daily Total	Buck	38	53	21	18	33	15	178
	Doe	40	59	16	32	22	7	176
	Fawn	10	18	6	12	8	1	55
	Unknown	14	18	13	23	16	6	90
Total		102	148	56	85	79	29	499

Second Week		Mon 11	Tues 12	Wed 13	Thurs 14	Fri 15	Sat 16	Total
Killed	Buck	2	1	1	-	2	2	8
	Doe	5	1	-	1	3	1	11
	Fawn	2	1	-	-	1	2	6
Seen	Buck	2	3	-	1	-	-	6
	Doe	9	7	4	2	5	6	33
	Fawn	1	1	1	1	1	2	7
	Unknown	6	3	-	6	2	8	26
Missed	Buck	2	-	1	2	2	4	11
	Doe	-	-	-	2	-	1	3
	Fawn	-	-	-	-	-	-	-
	Unknown	-	-	-	-	-	-	-
Wounded	Buck	-	-	-	-	-	1	1
	Doe	-	-	-	-	-	-	-
	Fawn	-	-	-	-	-	-	-
	Unknown	-	-	-	-	-	-	-
Daily Total	Buck	6	4	2	3	4	7	26
	Doe	14	8	4	5	8	8	47
	Fawn	3	2	1	1	2	4	13
	Unknown	7	3	-	6	2	8	26
Total		30	17	7	15	16	27	112

TABLE 7. Groups of deer observed (N = # of reports)

Number of deer in group	Occurrence 1980 (N=46)	1981 (N=83)	1982 (N=57)	1983 (N=89)	1984 (N=113)	1985 (N=80)
2	32	57	41	63	98	57
3	11	20	10	22	23	19
4	2	4	4	2	9	1
5	1	1	-	1	1	1
6	-	1	2	1	2	1
7	-	-	-	-	-	1
Total Deer	110	201	140	211	318	193*

* Includes 24 deer killed.

TABLE 8. Hunter groups using dogs during 1985 hunt.

Type of Hunter Group	Number without dogs	Number with dogs	No. of dogs	No. of dogs per hunter group
Hunt camp	32	45	143	3.2
Tent camp	11	4	5	1.2
Casuals	22	3	4	1.3
Total	65	52	152	2.9

TABLE 9. Summary of hunting effort and use of dogs on CSA - 1985 hunt.

	First Week Dogs(%)	First Week No dogs(%)	Second Week Dogs(%)	Second Week No dogs(%)	Total Dogs(%)	Total No dogs(%)
MD effort*	1526 (60)	1017 (40)	258.5 (43)	339 (57)	1784.5 (57)	1356 (43)
Kill	37 (32)	77 (68)	9 (36)	16 (64)	46$_t$ (33)	93$_t$ (67)
Obs **	162 (32)	337 (68)	37 (33)	75 (67)	199$_t$ (33)	412$_t$ (67)
MD/kill	41.2	13.2	28.7	21.2	38.8	14.6
MD/Obs	9.4	3.0	7.0	4.5	9.0	3.3

* Man-days effort.
** Observations include harvested deer.
$_t$ Combined total represents 97% of total observations

TABLE 10. Daily observations and hunting effort with and without days on CSA - 1985 hunt.

First Week		Mon D	Mon ND	Tues D	Tues ND	Wed D	Wed ND	Thur D	Thur ND	Fri D	Fri ND	Sat D	Sat ND	Total D	Total ND
Effort (Man-days)		227	176	323.5	209.5	215.5	166.5	291.5	188	295.5	186.5	173	90.5	1526	1017
Killed	Male	3	9	6	14	-	7	3	5	4	10	2	6	18	51
	Female	2	2	3	7	2	1	2	2	1	1	-	1	10	14
	Fawn	1	1	3	4	-	2	4	1	1	3	-	1	9	12
Seen	Male	3	6	2	9	-	5	1	2	2	1	-	-	8	23
	Female	8	23	13	31	4	8	6	16	7	13	1	4	39	95
	Fawn	3	5	5	5	-	3	2	5	1	3	-	-	11	21
	Unknown	4	10	4	13	4	7	6	15	7	9	4	2	29	56
Missed	Male	5	10	5	13	2	5	1	5	5	9	3	3	21	45
	Female	2	3	3	-	-	-	1	3	-	-	1	-	7	6
	Fawn	-	-	1	-	1	-	-	-	-	-	-	-	2	-
	Unknown	-	-	-	1	2	-	1	1	-	-	-	-	3	2
Wounded	Male	-	2	-	4	1	1	-	1	-	2	-	1	1	11
	Female	-	-	1	1	1	-	2	-	-	-	-	-	4	1
	Fawn	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Unknown	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Daily Total	Male	11	27	13	40	3	18	5	13	11	22	5	10	48	130
	Female	12	28	20	39	7	9	11	21	8	14	2	5	60	116
	Fawn	4	6	9	9	1	5	6	6	2	6	-	1	22	33
	*Unknown	4	10	4	14	6	7	7	16	7	9	4	2	32	58
Total		31	71	46	102	17	39	29	56	28	51	11	18	162**	337**

Second Week		Mon† D	Mon† ND	Tues D	Tues ND	Wed D	Wed ND	Thur D	Thur ND	Fri D	Fri ND	Sat D	Sat ND	Total D	Total ND
Effort (Man-days)		51	78.5	36	65.5	14.5	59	44.5	36.5	69	57	43.5	42.5	258.5	339
Killed	Male	-	2	1	-	1	-	-	-	-	2	1	1	3	5
	Female	2	3	-	1	-	-	-	1	1	2	1	-	4	7
	Fawn	-	1	1	-	-	-	-	-	-	1	-	2	2	4
Seen	Male	-	2	-	3	-	-	-	1	-	-	-	-	-	6
	Female	3	6	4	3	2	2	1	1	1	4	4	2	15	18
	Fawn	-	1	-	1	-	1	-	1	1	-	2	-	3	4
	Unknown	1	6	1	2	-	-	2	4	-	2	2	6	6	20
Missed	Male	-	2	-	-	-	1	-	2	1	1	-	4	1	10
	Female	-	-	-	-	-	-	2	-	-	-	-	1	2	1
	Fawn	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Unknown	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Wounded	Male	-	-	-	-	-	-	-	-	-	-	1	-	1	-
	Female	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Fawn	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Unknown	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Daily Total	Male	-	6	1	3	1	1	-	3	1	3	2	5	5	21
	Female	5	9	4	4	2	2	3	2	2	6	5	3	21	26
	Fawn	1	2	1	1	-	1	-	1	1	1	2	2	5	8
	*Unknown	1	6	1	2	-	-	2	4	-	2	2	6	6	20
Total		7	23	7	10	3	4	5	10	4	12	11	16	37**	75**

D - days
N - no days
* - 36% of unknown observations were identified as unknown antlerless deer.
** - Combined total for two week season represents 97% of total observations.
† - Sunday hunting included with records for Monday.

Deer Measurement and Age Data from the Canonto Check Stations, 1953-84

- Anne B. Lambert

During the Canonto Deer Study, two checking stations have been operated, one positioned on each of the two access roads to the study area. The southern check station, at Palmerston Lake, has been running since 1952, and the northern check station (near Barrett Chute) began operation in 1957, with the expansion of the study area into North Canonto and Blithfield Townships. Sex, age, and various body measurements are part of the information recorded on harvested deer brought out of the study area. The study area also includes boat accessible hunt camps on Norcan Lake and the Madawaska River, and here, deer are processed in the camps during and immediately after the hunt.

During 1985, a comprehensive analysis of Canonto measurement and age data was initiated. Beyond a basic, descriptive examination of the data, there were a number of specific areas to be investigated:

(1) the condition of study area deer relative to other herds, based on measurement means, the fawn:doe ratio, and percent lactating;

(2) a comparison of aging techniques and assessment of their relative merits;

(3) an interpretation of age frequency data and comparison with that of other hunted and non-hunted populations;

(4) changes through time in the condition and age composition of deer in the kill, and the relation of any changes to population size and winter severity;

(5) the usefulness of the various measurement parameters in assessing condition; and

(6) the general value of check station data.

A report of this study is expected to be completed in 1986. This article presents a brief sampling of the results of the analysis done so far.

For the years 1953 to 1984, there is information on 4258 deer killed in the study area. Processing a deer involved weighing the dressed carcass and taking the following measurements: heart girth, total length, hind foot length, udder condition (does), and number of

antler points (bucks). A height at withers measurement was taken until 1965, and beginning in 1976, antler beam diameter was recorded. All deer were sexed, and for 96%, toothwear age class was recorded. Incisors were removed from most jaws, and cementum age data are available for 42% of adults (including 58% of those deer aged 2.5 years or older). For many deer, especially those partly eaten in camp, various measurements are missing (see Table 1). Information was also collected on the circumstances of the kill (hunting method, presence of other deer, time of day, etc.), but these data are not part of the present analysis.

Before analysis could begin, the data had to be entered into computer files. Some of the data (1954-76) had been computerized for the purposes of an earlier study of headbone and body measurements. To this data set, additional variables were added, as well as data for the years 1953 and 1977 to 1984. A time-consuming period of error checking was then necessary.

The first stage of the analysis involved an examination of univariate statistics. For age/sex groups (0.5, 1.5, 2.5, etc. to 7.5, 8.5+ years), the following statistics were computed for each measurement variable: sample size, mean, median, standard error, minimum, maximum, and the upper and lower limits to the central 95% of the values (where N > 50). Kolmogorov-Smirnov Goodness of Fit Tests were carried out to test the assumption of normality. The significance of the differences between age groups was tested using T-tests for normal variables, and Mann-Whitney U-tests for non-normal variables. For each variable, older age groups not significantly different from each other were combined for subsequent analysis.

The only variables found to be significantly non-normal were hind foot length for both sexes and total antler points. For males, significant differences between consecutive age groups were found from age 0.5 to 5.5+ for weight, girth, total length, and beam diameter; and from 0.5 to 4.5+ for height at withers and total antler points. For females, significant differences were found between age groups 0.5 to 4.5+ for weight, girth, and total length, and between age groups 0.5 to 3.5+ for height at withers. For both sexes, foot length was significantly different for age groups 0.5 to 3.5+. Table 2 shows mean

Table 1. Description of data set.

N[a]	%	Var. name		Years taken
4258	100.0[b]	YEAR		all
4258	100.0[b]	AREA	North or South Canonto	all
4258	100.0[b]	SEX		all
4094	96.1[b]	AGET	toothwear age class	all
1277	30.0[b,c]	AGEC	cementum age	all
4149	97.4[b]	AGE	toothwear age (if avail.) or cementum age	all
3359	81.0[d]	WEIGHT	dressed weight in lbs	all
2998	72.3[d]	GIRTH	heart girth (chest circumference) in cm	1956-1984
3001	72.3[d]	LENGTH	total length in cm	"
3108	74.9[d]	FOOT	hind foot length in cm	1957-1984
1029	24.8[d]	HEIGHT	height at withers in cm	1956-1965
1084	86.2[e]	UDDER	udder condition (presence of milk in teats)	all
1520	94.2[f]	POINTS	total number of antler points	all
258	16.0[f]	BEAM	antler beam diameter in mm	1976-1984
1276	42.8[g]	INTERVAL	no. of days between kill and weighing	1957-1984

[a] Values of N for measurement data (variables WEIGHT to BEAM) exclude any unaged deer, since these measurements are not used in most of the analysis.
[b] N as percent of all cases.
[c] 42.4% of adults and 58.2% of age 2.5+ deer have AGEC data.
[d] N as percent of aged deer.
[e] N as percent of aged female adults.
[f] N as percent of aged male adults.
[g] N as percent of adult deer.

Table 2. Means of selected measurement variables for significantly (P=0.01) different age groups.

		DRESSED WEIGHT (lbs)			HEART GIRTH (cm)			TOTAL LENGTH (cm)			BEAM DIAMETER (mm)		
	Age	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.
MALES	0.5	479	68.0	8.5	454	75.2	4.5	450	152.7	7.8	-	-	-
	1.5	605	112.8	11.8	552	90.2	4.2	542	180.3	8.6	123	19.1	2.6
	2.5	287	144.8	14.2	262	98.0	4.4	257	190.1	8.8	56	26.1	3.2
	3.5	206	165.0	17.8	165	101.8	5.0	170	195.1	8.6	43	28.9	3.4
	4.5	153	184.3	16.6	123	104.9	4.4	123	199.1	8.7	22	33.6	4.3
	5.5+	142	197.2	21.0	121	107.2	5.4	115	202.0	9.0	14	37.9	4.6
FEMALES	0.5	432	62.7	7.9	408	73.6	4.0	417	149.3	7.6			
	1.5	313	96.2	9.2	284	86.2	4.0	292	172.0	7.3			
	2.5	266	104.0	10.9	227	89.1	3.9	223	176.4	8.1			
	3.5	169	107.8	10.5	141	90.2	4.2	147	179.3	7.4			
	4.5+	307	115.4	11.0	261	92.8	4.0	165	182.3	7.7			

values for selected variables, while Fig. 1 illustrates the relation between mean weight and age. Differences in mean weights are quite substantial up to age 5.5 for males and 4.5 for females. This implies that combining any of these lower age groups (as is sometimes done) would produce means that have little comparative value, especially since age composition is highly variable.

The "Age" variable finally used was based both on toothwear and cementum data, but predominantly the former. Cementum age data were used only where toothwear age was not available. The explanation for this procedure is as follows. First, there is error in both methods: cementum aging (using deer incisors) is not, as it is sometimes assumed, 100% accurate. Secondly, there were two different methods used for cementum annuli aging. The isomet saw technique used from 1980 to 1983 has proven to be substantially less accurate (for deer incisors) than the microtome sectioning method used from 1953 to 1978 and in 1984. Toothwear aging, on the other hand, is believed to be highly consistent throughout the study. More importantly, there is a high degree of correspondence between the two methods: the two values matched in 82.6% of 1092 cases with both types of age data in the period 1954 to 1976, indicating a degree of accuracy in toothwear aging much higher than that generally found. From Table 3, which shows toothwear age expressed as mean cementum age for these paired data (1954-76), it is clear that differences between the methods are minimal until age 6.5 and over. For these older age classes, cementum age averages 0.57 years (N = 110) higher than the corresponding toothwear age. Furthermore, using this same data set, the means and variance of measurement variables calculated using age groups determined by the two methods are extremely similar. Finally, when cases in which there was a discrepancy between the two ages were examined, the measurements did not suggest that one or other of the methods would place more cases in the 'correct' age group. In conclusion, since the two aging methods are of roughly equal value when used with measurement data (especially when older age groups are pooled), toothwear age, which is available for all years and for most (96%) cases, was used in preference to cementum age.

"Udder condition" in adult does was decermined as presence or absence of milk in teats. This measurement tends to underestimate the

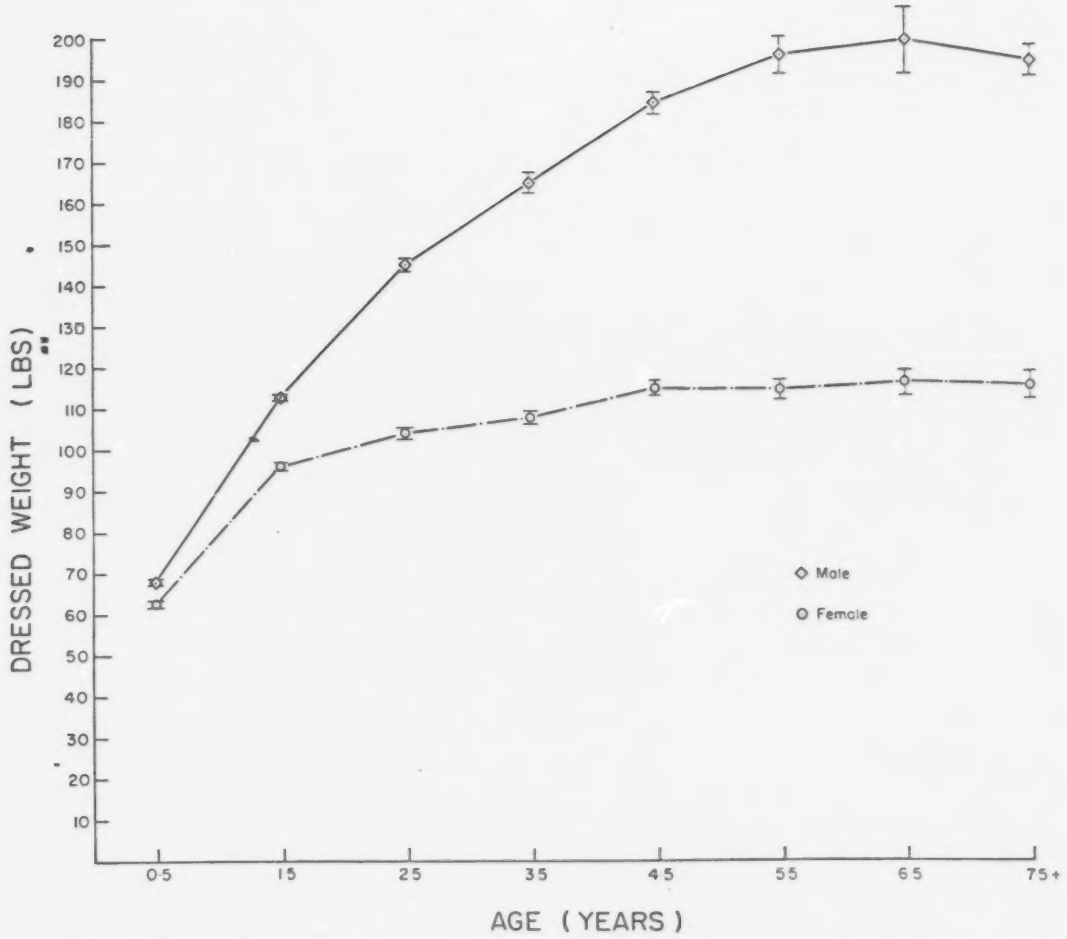


Figure 1. Mean dressed weight versus age for males and females in the Canonto kill, 1953 - 1984. Horizontal bars indicate 95% confidence interval about the mean.

Table 3. Toothwear age expressed as mean cementum age for paired toothwear age/cementum age data from the period 1954-1976.

N	(a) Toothwear age class (years)	(b) Mean cementum age (years)	difference (b)-(a)
4	0.5	0.500	0.000
130	1.5	1.500	0.000
345	2.5	2.538	0.038
226	3.5	3.491	-0.009
171	4.5	4.623	0.123
101	5.5	5.708	0.208
51	6.5	7.029	0.529
23	7.5	8.196	0.696
11	8.5	8.955	0.455
13	9.5	10.115	0.615
3	10.5	11.167	0.667
4	11.5	13.000	1.500
3	12.5	11.833	-0.667
2	13.5	14.000	0.500

Table 4. Proportions of lactating (L) and non-lactating (NL) does by age group, all years (1953-1984) combined. The terms lactating and non-lactating refer to whether or not milk was found in teats.

Age	N	Percent lactating	P*	Total Number L	NL	U**
1.5	331	6.9		23	308	54
2.5	268	81.3	<.005	218	50	43
3.5-7.5	450	90.9	<.005	409	41	69
8.5+	35	74.3	<.005	26	9	7

* Significance of Chi-square statistic for comparing proportion with that of preceding age group.

** Udder condition unknown.

true percentage of does that raised fawns in that year; nevertheless, clear differences are evident between the following four age groupings: 1.5, 2.5, 3.5 to 7.5 (combined), and 8.5 and over (Table 4). A further analysis (not detailed here) revealed that in all age groups, lactating does weighed less (by roughly 5%) than non-lactating does, after taking linear size (total length) into account.

Measurement variables tend to be correlated with each other, to varying degrees. Table 5 shows results for males; results are similar for females but correlation coefficients are all lower. Results of principal component analysis (not shown here) indicate that while most

Table 5. Nonparametric correlation coefficients between measurement variables for adult bucks, age groups combined. All correlations are significant (P<0.001). WEIGHT= dressed weight; GIRTH= heart girth; LENGTH= total length; HEIGHT= height at withers; BEAM= beam diameter; FOOT= hind foot length; POINTS= number of antler points.

	Correlation coefficients * (sample size)**					
	GIRTH	LENGTH	HEIGHT	FOOT	BEAM	POINTS
WEIGHT	0.923 (400)	0.817 (400)	0.714 (293)	0.634 (400)	0.873 (203)	0.616 (293)
GIRTH	-	0.766 (400)	0.651 (293)	0.582 (400)	0.796 (203)	0.568 (293)
LENGTH		-	0.617 (293)	0.628 (400)	0.647 (203)	0.452 (292)
HEIGHT			-	0.629 (293)	-	0.384 (329)
FOOT				-	0.450 (203)	0.324 (293)
BEAM					-	0.714 (260)

* Values for POINTS are Kendall's tau; all others are Spearman's rho.

** These are random samples of a larger data set.

of the joint variation among measurement variables is due to a general 'growth' or 'size' component, a substantial amount of the variation is due to other factors. One of the other components contrasts weight and girth with linear measurements, dealing therefore with variation in body shape. This is probably a reasonable approximation of a 'condition' factor, although some unknown part of it may have a genetic basis.

Comparison of mean weights from Canonto with those from other herds in New York and Michigan suggests that Canonto deer have been in good or very good (although not optimal) condition. Canonto means for various age/sex groups are similar to those in the New York regions with the best range quality. During the long course of the Canonto study, there have not been large fluctuations or dramatic trends in yearly measurement means. Analysis of variance does show a significant year effect in all variables, however, and regression analysis (using year, sex and age terms) indicates a significant downward trend in many measurement variables in the early part of the study, and a period of increasing values in the latter part of the study. In graphs plotting yearly means of weight and number of antler points against year, these trends are apparent but not striking. There does not appear to have been a period in which the herd was under a particular 'habitat stress', and yet the slightly higher weights and mean antler points in the period after 1976 seem to imply an improvement in the local food supply, perhaps brought about by the low herd levels of the 1970's, (or possibly the effect of increased local logging activity).

The age composition of the kill (Table 6) reveals a significant number of older deer (up to 13.5 years in age), and presents a picture of a herd that is only moderately hunted, compared with very heavily hunted populations in which there is a preponderance of yearlings and 2.5-year-olds in the adult kill. A striking difference between the male and female components of the kill in the proportion of yearlings to older deer probably reflects higher vulnerability of male yearlings, and may also reflect hunter preference for antlered deer. While the fawn sex ratio is roughly equal, males make up 62% of yearlings in the kill in the years before selective harvest. The remainder of the adult kill also suggests a disproportionate hunting pressure on the increasingly reduced male segment, such that females make up the majority of older

(5.5+) deer. In the selective harvest years (1980-84), the increased proportion of younger age groups, particularly yearlings, in the adult kill reflects a population that was increasing (as determined by harvest and hunting effort data) as a result of the reduced antlerless kill.

Table 6. Age composition of the kill, in the periods before selective harvest (1953-1979) and with selective harvest (1980-1984).

	FEMALES					
	1953-1979			1980-1984		
Age	N	as % of aged deer	as % of aged adults	N	as % of aged deer	as % of aged adults
0.5	606	33.4		15	23.4	
1.5	368	20.3	30.5	17	26.6	34.7
2.5	300	16.5	24.8	11	17.7	22.4
3.5	182	10.0	15.1	8	12.5	16.3
4.5	140	7.7	11.6	3	4.7	6.1
5.5	101	5.6	8.4	4	6.3	8.2
6.5	50	2.8	4.1	3	4.7	6.1
7.5	26	1.4	2.2	2	3.1	4.1
8.5	14	0.8	1.2	1	1.6	2.0
9.5	12	0.7	1.0			
10.5	3	0.2	0.2			
11.5	5	0.3	0.4			
12.5	4	0.2	0.3			
13.5	3	0.2	0.2			
Total aged	1814			64		
Unaged	61			1		
TOTAL	1875			65		

	MALES					
	1953-1979			1980-1984		
Age	N	as % of aged deer	as % of aged adults	N	as % of aged deer	as % of aged adults
0.5	650	31.5		7	3.4	
1.5	609	29.5	43.2	106	51.0	52.7
2.5	294	14.3	20.7	37	17.8	18.4
3.5	207	10.0	14.6	31	14.9	15.4
4.5	156	7.6	11.0	14	6.7	7.0
5.5	75	3.6	5.3	9	4.3	4.5
6.5	39	1.9	2.8	3	1.4	1.5
7.5	19	0.9	1.3			
8.5	6	0.3	0.4			
9.5	4	0.2	0.3	1	0.5	0.5
10.5	2	0.1	0.1			
11.5						
12.5	2	0.1	0.1			
Total aged	2063			208		
Unaged	36			11		
TOTAL	2099			219		

RABIES

Prevention of Rabies in Ontario Wildlife - C.D. MacInnes

(Paper presented at 53rd Conjoint Meeting on Infectious Diseases, November 25-27, 1985, Toronto)

Rabies is enzootic in 86,000 km^2 of agricultural southern Ontario. Prior to 1956, there was no rabies known in wildlife in the Ontario area. Outbreaks among domestic animals lasted only a few years each, and were usually localized. Wildlife rabies came from the arctic, and was moved from James Bay into southern Ontario by red foxes (Tabel et al. 1974).

Over the 29 years since the invasion, southern Ontario has consistently had the highest density of diagnosed animal rabies cases of any comparable area in North America. The recent spread of raccoon rabies in the eastern United States has produced high local densities, but Ontario still has the dubious distinction of being highest. Diagnosis records must be compared with caution, because regulations, and methods of collecting and reporting case records differ widely among jurisdictions.

When the invasion from the north was in progress, there was a rabies outbreak in the clay belt agricultural lands in northeastern Ontario, but that has died out. The invasion pushed through southern Ontario into Quebec, New York and the Maritime Provinces. With the exception of parts of Quebec and New York close to the Ontario enzootic area, wildlife rabies has become rare in those areas.

A similar invasion of fox rabies has moved across western Europe. It started in the USSR or Poland in the 1940's, reached France in 1968, and is now close to the English Channel. One historical point is interesting. Apparently there was wildlife rabies in France in foxes and wolves, in the first half of the last century. Fragmentary evidence suggests that the disease died out by 1850, having persisted 30-50 years in any locality. Interpretation of the old accounts is difficult, because rabies persisted in dogs, and other domestics.

We do not fully understand why the disease has persisted in southern Ontario. Here are some perspectives: Voigt and Tinline (1982) identified twelve rabies cells within southern Ontario. A 'cell'

contains areas of similar fox rabies incidence. Cells may differ from each other not only in the year of a rabies outbreak, but in the predictability or regularity of outbreaks, in the season of the year when outbreaks begin, and in the average severity of outbreaks. In terms of persistence of enzootic rabies, a key feature seems to be that rabies outbreaks in the twelve cells are not synchronized. Why is that important? After an outbreak within a single cell, rabies may die out locally. Fox density is severely reduced in the aftermath of an outbreak. The interval between outbreaks seems to depend upon the time required to restore fox density to a level where rabies can move readily. With twelve cells fluctuating, the probability of a rabies-free cell being infected by a rabid fox dispersing from a nearby cell is appreciable. Modelling studies to date have shown that it is quite likely, over a 5-15 year period, that rabies will disappear from a single cell, so reinfection may be a key to long-term persistence. This property is widely variable.

Voigt (unpublished) studied movements of over 100 red foxes by radiotelemetry. Dispersal over distances large enough to move rabies between cells does occur regularly. The most frequent dispersers are juvenile males. The average distance moved by males from natal home range to first breeding range is 15.0 km, but about 5 individuals out of every 100 will move over 100 km during September-November of their first year.

This is the context within which we must work to control rabies in Ontario: a large area, 86,000 km^2 has persistent enzootic rabies, vectored by foxes and skunks. There is little evidence that rabies is transmitted among domestic animals, meaning that foxes or skunks are the source of infection for almost all domestic animal rabies (Table 1).

Up to the present, there has been little attempt to reduce rabies in wildlife in Ontario. Humans are protected against infection by a well-organized system for post-exposure immunization. Agriculture Canada, the Ontario Ministry of Health and the Ontario Veterinary Association have used various programs to facilitate immunization of pets. In recent years the Ministry of Health has increased its publicity to encourage vaccination of pets. There is currently no estimate of the proportion of dogs and cats which are vaccinated.

Table 1. Cases of rabies diagnosed in southern Ontario, 1956-80, and number of humans treated for rabies in 1980.

Species	Reported rabies cases*		Source of exposure for humans treated for rabies, 1977-1980**	
	No.	%	No.	%
Red fox	12402	45	280	8
Cattle	5796	21	448	13
Skunk	4361	16	72	4
Dog	1715	6	1328	39
Cat	1388	5	687	20
Other domestic	1541	5	161	10
Other wildlife	545	2	162	10

* Only animals that have exposed humans or domestic animals to danger of rabies infection are submitted for diagnosis. Therefore many animals suspected of being rabid are not submitted. Data from Agriculture Canada.

** These figures show sources of exposure to both diagnosed rabid animals and cases where rabies was only suspected. Data from Honig (1985).

Riding horses for hire and animals in petting zoos must be vaccinated. Pet vaccinations may become mandatory. Cattle, swine and other species for farm production are not subject to any organized vaccination scheme. In 1968, the Ontario Government appointed an inter-departmental committee to examine options for dealing with the 10-year-old outbreak of rabies. Three choices were available.

1. Wait for wildlife rabies to die out.
2. Reduce vector populations to lessen the frequency of infected wildlife.
3. Vaccinate wild species.

I find it hard to establish the mental context of 1968, so what follows has the advantage of seventeen years of hindsight.

Option 1: Wait for rabies to die out.

Even in 1968, the epizootic in central Europe was still on the increase after almost twenty years. The history of outbreaks in the 19th Century was not well known in 1968. The extent to which land use differences between the 19th and 20th centuries may affect persistence of rabies is unknown. In 1968, the Ontario outbreak was persisting at a high level, as it still is in 1986. In fact, there was a very high incidence of rabies in 1967, and a little girl died of the disease, near Ottawa. Thus, there was nothing to indicate that the outbreak might die out in a finite time. In 1985, there is still no sign of the enzootic weakening.

Option 2: Reduce vector populations to eliminate rabies.

The literature on population reduction is discouraging. However, three situations must be separated.

(1) If a rabies outbreak in an area previously lacking rabies is detected very early, theory states that extensive local killing of vectors may eliminate rabies. There are no well-documented examples of this, although some papers claim success.

(2) The two apparently most successful examples of population reduction affecting rabies involved population control zones established in advance of a rabies epizootic front. These zones were intended to prevent rabies from advancing. Danish authorities have maintained a control zone across the Jutland isthmus off and on since the early 1960's. There have been rabies cases north of the zone, but overall peninsular Denmark has remained rabies-free. In Canada, Alberta established a skunk control zone along the Saskatchewan border. Gunson et al. (1978) operated in low skunk densities, aided by the fact that most skunks winter under buildings and are therefore relatively easy to find. The control zone was established in 1971, and appeared successful until 1979, when skunk rabies became established in about 3000 km^2 of southeastern Alberta (Rosatte et al. in press).

(3) Population reduction within a large area of enzootic rabies. When the initial invasion of rabies from the arctic swept across the prairies in 1952-53, Alberta conducted large scale poisoning and trapping, estimated to have killed 180,000 coyotes and red foxes (Ballantyne 1958). Rabies died out by 1958, and was not seen again

until skunk rabies became a problem. However, rabies also died out in the same period in northern Saskatchewan and Manitoba, without any control.

Other than that case, no widespread control program has eradicated rabies, or had a noticeable long-term effect on numbers of cases. Trapping definitely affects the prevalence of rabies. Voigt and Tinline (1982) explored the relation between rabies and trapping of foxes for fur in southern Ontario: "High levels of harvest in southern Ontario can decrease the severity, if not the frequency, of rabies outbreaks."

MNR receives periodic requests to use a bounty to reduce foxes. In the period 1973-1983, there was no bounty, but the price of an average red fox pelt averaged over $58.00, which is many times higher than any bounty ever offered for foxes (Figure 1). The numbers both of rabies cases and of fox pelts sold fluctuated more than two-fold in the eleven-year period, but there was no lasting upward or downward trend. There is little correlation between price and pelts harvested ($r=0.28$), or pelts and rabies cases ($r=0.35$), but it is worth noting that the relation between pelts and rabies is positive, suggesting that years of high fox harvest sometimes also have many rabies cases. The weakness of the relationship suggests that trapping at current levels has little influence on rabies. The fur harvest probably removed, across southern Ontario as a whole, about 15% of the fall population. Even in Huron County, where about 15 skilled and persistent trappers have specialized in catching foxes, the annual take rarely exceeds 50% of the available fox population. Southern Ontario fox populations are quite capable of sustaining long-term annual mortality of at least 60%. The average litter size is 8 pups.

Trappers working for sale of fur, or a bounty, are paid per fox: that is piece work. As foxes become scarcer, the return per unit time or effort drops, eventually to an unprofitable level. Even if much of a fall fox population is killed, one spring's reproduction will replace many losses. Increasing harvest from 50% to 80% or more would require many times the effort already expended.

Experienced trappers indicate that, if foxes and skunks are to be kept at very low levels, roughly one trapper should be assigned to each township. Such an individual would have to be on salary for at least 8

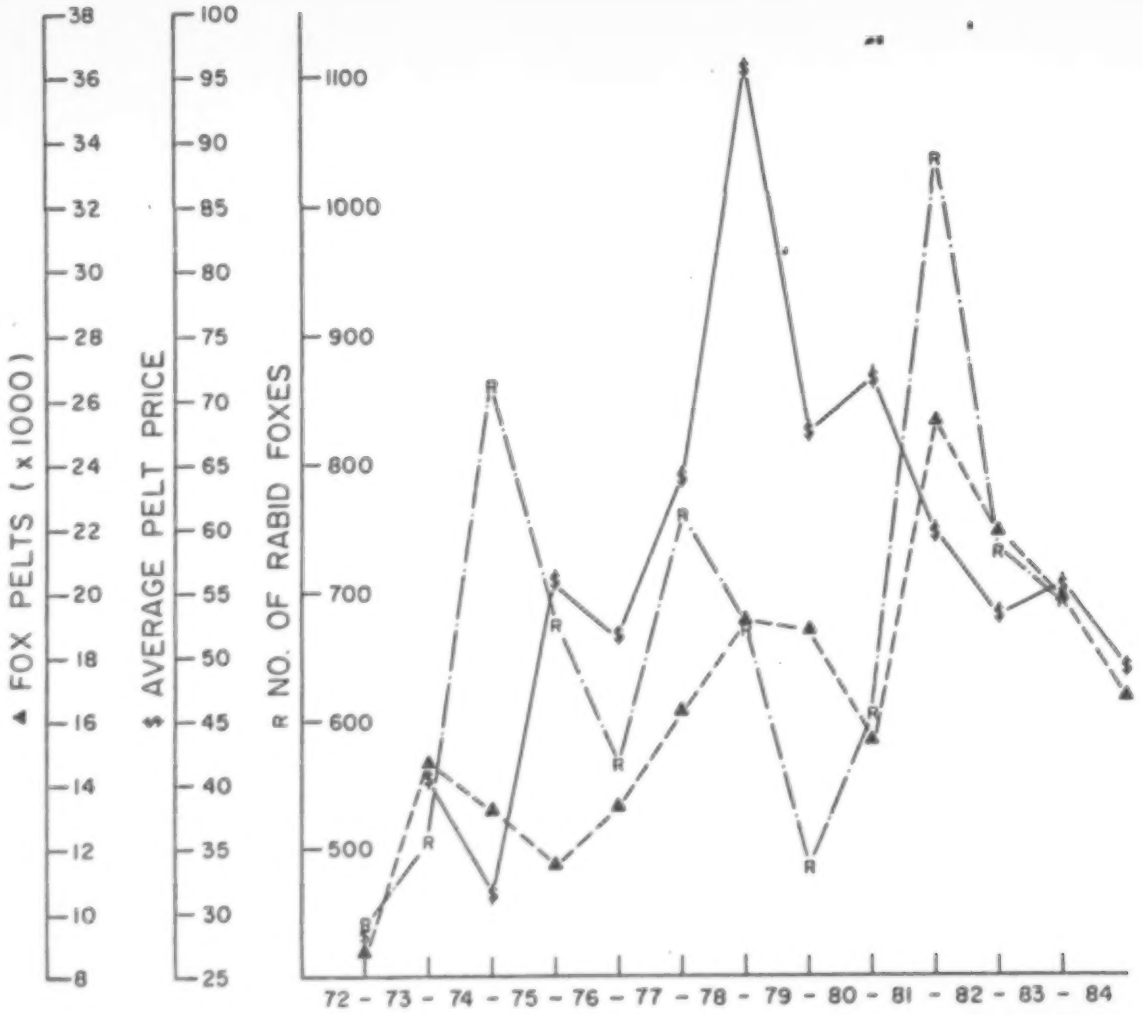


Figure 1. Fox pelts harvested, average price per pelt, and total fox rabies cases, in southern Ontario, from 1972 to the present. (A year is taken as 1 July - 31 June, because trapping, and rabies outbreaks occur mostly during fall and winter).

months each year to be effective. There are 481 townships in the rabies zone of southern Ontario, so the overall cost for salaries alone would be over $8 million, and the total program would likely come in at $14 million per year.

Any attempt to reduce foxes and skunks to such a low level would encounter significant opposition from many quarters.

Option 3: Vaccinate wildlife against rabies.

In 1968, the Interdepartmental Rabies Committee decided that the most viable option was vaccination. They were aided in that decision by a World Health Organization Expert Committee on Rabies recommendation that vaccination seemed to be the most likely route to significant reduction of rabies in wildlife.

Over the following decade there developed a comprehensive research program with a clear target: an economical system to vaccinate wild foxes and skunks against rabies. This program has been especially interesting because of the number of different scientific disciplines involved (Figure 2). It is one of the largest research programs ever mounted by a wildlife agency. Scientific direction is by an advisory committee composed of experts from universities and from both the federal and provincial governments. Much of the work has been contracted, to Connaught Labs, Queen's University, and the Universities of Toronto, Guelph, and Saskatchewan. The Animal Diseases Research Institute of Agriculture Canada has been an enthusiastic cooperator. The MNR Rabies Research Unit played important roles in bait development and delivery, and in various field studies. The spirit of cooperation has been outstanding. Table 2 shows how the contractors fit the flowchart.

The greatest part of our investment has gone into vaccine development. In the early 1970's, attention focussed on Modified Live Virus (MLV) vaccines, which we proposed should be absorbed through the oropharyngeal mucosa. Concerns were raised about safety, if such a vaccine were to be distributed widely in the field. By the late 1970's, good Killed-Virus (KV) vaccines were available for veterinary use. Such preparations did not work by the oropharyngeal route, but experiments showed that, if the material is introduced into the small intestine of foxes, 30-50% of animals will produce antibody after two doses. A great

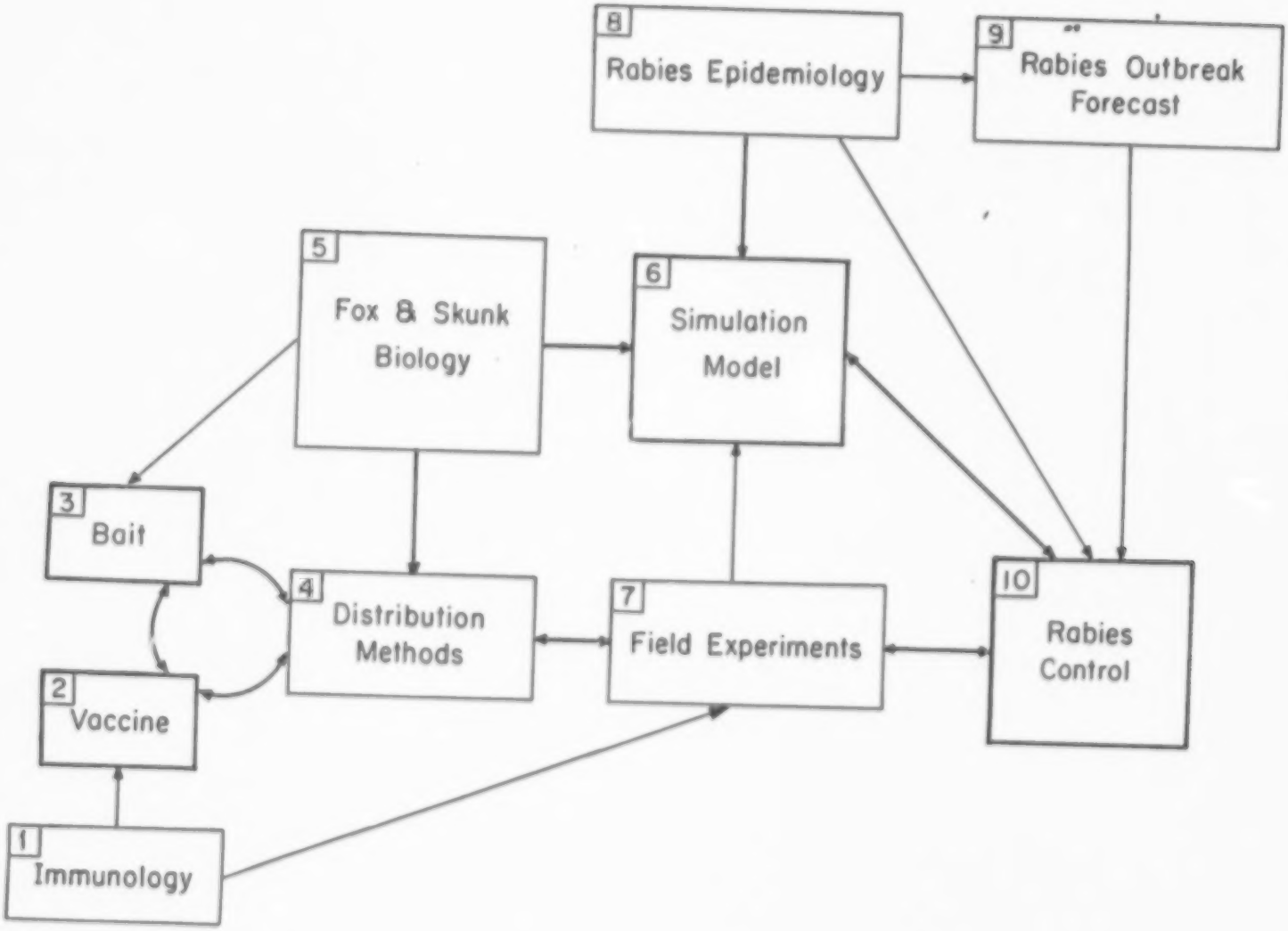

8
Rabies Epidemiology
9
Rabies Outbreak Forecast
5
Fox & Skunk Biology
6
Simulation Model
3
Bait
4
Distribution Methods
7
Field Experiments
10
Rabies Control
2
Vaccine
1
Immunology

Figure 2.

Table 2. How contractors fit the flowchart (Figure 2).

PARTICIPANTS

Name and Organization	Subject	Flowchart Boxes
K.F. Lawson, Connaught Laboratories Ltd.	Development and testing of live- and killed-virus vaccines for oral administration to foxes	1,2,7
	Experiments with fox baits	3,4
J.B. Campbell, University of Toronto	Encapsulation of vaccines	2,3
	Immune response to rabies antigen	1
	Assessment of serum antibody	1,7
	Vaccine development (i) Killed virus	2
	(ii) Recombinant DNA	2
R.B. Stewart, Queen's University	Properties of live rabies vaccines	1,2
	Selection of new vaccine strains	2
	Identification of rabies viruses	1
K.M. Charlton, Animal Diseases Research Institute, Agriculture Canada and R.B. Stewart & N. Tolson, Queen's University	Development of live, apathogenic rabies vaccines	2
	Development of live vaccine for skunks	2
	Experiments with recombinant DNA rabies vaccines	2
R. Tinline & L. Broekhoven, Queen's University	Simulation model of rabies outbreaks to test control strategies (with D.R. Voigt of MNR)	6,8,9
	Rabies outbreak forecast	9
H. Tabel, University of Saskatchewan	Immune responses of skunks to rabies vaccines	1
B.N. Wilkie & J.B. Derbyshire, University of Guelph	Immune responses of skunks to killed virus rabies vaccine	1
W.D. Black, University of Guelph	Antibiotic residues in milk and meat following ingestion of rabies baits	3,4
Rabies Unit, Ministry of Natural Resources	Dispersal and ecology of foxes, skunks, raccoons, and coyotes	5
	Baits and distribution to deliver rabies vaccine to wild species	3,4,7
	Strategies for control of wildlife rabies in urban environments	7,8
	Rabies history and epidemiology in Ontario	8,9

deal of effort went to improving that performance, but the goal eluded us. Therefore, in 1984, interest returned to MLV vaccine, which was by then being used in the field in Switzerland and Germany.

The very recent advent of genetically engineered rabies vaccine is exciting. Human smallpox vaccine, a virus called vaccinia, has been modified by adding to it the genes which code for the surface (G) protein of rabies. This new virus is effective in skunks and raccoons, which do not seroconvert when receiving MLV rabies by mouth. We are actively examining that field, but a vaccine for widespread use in the field still seems a few years away, at least. In the interim, we wish to see if a suitable MLV preparation can be found to get rabies control started.

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Urban Rabies Program - R. C. Rosatte

Most reported rabies cases in foxes and skunks are from the rural areas of southern Ontario. However, skunks are also commonly diagnosed rabid in city areas. Greater numbers of rabid skunks (109) were diagnosed in metropolitan Toronto during the 5-year period 1 April 1980-31 March 1985, than during the preceeding 10 years (1970-1979) (73) (Fig. 1). Metro Toronto rabid skunks also constituted 56% of all the diagnosed skunk cases in York County between 1 April 1980 and 31 March 1985 (109/194). As well, human post-exposure treatment due to contact with potential rabid animals in metro Toronto during 1984 represented 10% (192) of the total exposures for all of Ontario (2,027) (Table 1). The current oral rabies vaccine is not effective in skunks. Therefore another approach for controlling rabies in urban areas is necessary.

During the spring of 1984 a preliminary investigation into the movements and habits of urban skunks was initiated in metro Toronto under a Canada Works Section 38 program. Raccoons were studied as well. Only 12 raccoons were diagnosed rabid in Ontario during 1984, but we felt it essential to gain background information on raccoons due to their great numbers in metro Toronto, in case control of rabies in that species is necessary in the future. A follow-up program was initiated in 1985, under the direction of the Rabies Advisory Committee, to examine the feasibility of a control strategy for rabies in urban wildlife.

Study Areas and Methods

The study areas encompassed portions of metropolitan Toronto, a 600-km^2 urban complex. During 1984, skunks and raccoons were radio-collared in a variety of land-use areas including residential, industrial, parkland, field, cemetery and ravine. The 1985 study focussed on 3 study areas within metro Toronto. Study area No. 1, located in Scarborough, consisted of 60% field, 35% residential and 5% industrial land-use areas. Study area No. 2 in the city of Toronto was 40% residential and 60% forested park and cemetery. Study area No. 3, located in Scarborough, consisted of 40% cemetery, 30% residential and 30% field-forest habitat.

These areas were selected from a human land-use map to include at each site a diversity of habitats. Each area (approx. 0.25 km^2) was

divided into trapping grids, each 100 m x 100 m. Three different-sized traps (Tomahawk #105 skunk, #106 rabbit, #108 raccoon) were placed in each grid to determine if a particular trap size was selective for any one species. The 3 study areas were trapped one at a time in succession for 10-day periods (9 nights) with 4 days off between trapping sessions during the period 3 June-15 November 1985. That allowed each area to be trapped 4 different times, enabling the blood sampling of recaptured animals to test vaccine effectiveness.

Between May and September, 1984, skunks and raccoons were live-trapped (Tomahawk #108, #106) in an attempt to radio-collar 20 skunks and 10 raccoons. Selected areas within Scarborough, York, Toronto, East York, North York, and Etobicoke were trapped in response to residents phoning in locations of skunks and raccoons following a news-release. Upon capture, animals were immobilized and processed: that included extraction of a pre-molar tooth for aging (adults only), sexing, measurements and weight taken, ear-tags for identification, and blood sampling via cardiac puncture for serum antibody analysis. Processed animals were vaccinated with Imrab inactivated rabies vaccine and then fitted with a radio collar. Collared animals were released at the point of capture. Locations of collared animals were usually determined once a day, Monday through Friday, May 1984-March 1985.

Each area was canvassed prior to setting traps to inform residents of the program, gain permission to trap on private property, and show residents how to release and reset traps should their pets become captured.

Preliminary Study

Trapping Success - Nine hundred and twenty-two captures were made between May 1984 and March 1985 including 474 (51%) raccoons, and 139 (15%) skunks. Cats accounted for 85% (262) of the 309 "other" species captured. Trapping success was greater in May-October than November-March. Few animals were trapped between December-March, however raccoons were captured more often than skunks during this period (Table 2).

Movements - Raccoons: Twelve adult raccoons were collared between 23 May and 21 June 1984. Home ranges and movements were determined up to the date of re-capture which ranged from 19 October 1984-22 April

Table 1. Number of people receiving post-exposure rabies treatment per animal species involved - 1984.

Health Unit Area	Total	Cat	Dog	Cattle	Other Domestic	Fox	Skunk	Raccoon	Bat	Other
Scarborough	39	5	22	-	-	3	1	1	4	2
East York	4	-	3	-	-	-	-	-	-	1
North York	44	3	23	-	-	9	-	3	4	2
Toronto City	88	10	54	-	1	7	-	7	2	7
York Borough	5	-	4	-	-	-	-	1	-	-
Etobicoke	12	-	7	-	-	1	-	1	3	-
Metro Toronto	192	18	113	-	1	20	2	13	13	12
Ontario	2027	458	656	227	64	224	126	65	78	129

Table 2. Preliminary Study Trapping Success (May 1984-March 1985)

Month	Trap Nights	No. of Raccoons[1]	No. of Skunks[1]	No. of Others[1]	Animals per trap night
May	277	52	1	32	0.31
June	309	54	11	40	0.34
July	156	8	25	23	0.36
August	756	140	49	47	0.31
September	743	95	6	50	0.20
October	324	36	17	51	0.32
November	424	34	17	44	0.22
December	248	16	6	19	0.17
January	196	13	3	0	0.08
February	229	22	1	0	0.10
March	98	4	3	3	0.10
Total	3760	474	139	309[2]	$\bar{x}$ = 0.25

[1] includes recaptures

[2] included 262 cats, 21 groundhogs, 11 rats, 7 black squirrels, 4 red fox, 1 dog, 1 mink, 1 cottontail rabbit.

1985. The average home range of 10 adult radio-collared raccoons (6 males, 4 females) was 0.42 km^2 (range 0.07-1.37 km^2). The average distance moved from point of capture was 0.8 km (range 0.3-1.8 km). Raccoons were sometimes active during the winter period with movements up to 1 km occurring between November and March.

Skunks: Twenty-nine (12 adult, 17 juvenile) skunks were collared between 1 June and 26 September 1984. Only 15 (9 adults, 6 juveniles) of the 29 collared animals could be used for home range and movement determinations due to collar malfunctions and slipped collars. Mean home range of adult skunks was 0.65 km^2 (range 0.08-1.44 km^2). The average distance moved from the point of collaring was 0.86 km (range 0.4-2.1 km). Juvenile skunks moved an average of 1.3 km (range 0.5-2.6 km) from the point of capture and had a mean home range of 0.63 km^2 (range 0.05-1.88 km^2). Skunks did not move any appreciable distance outside their dens during the winter with few movements occurring between November and February.

Denning Sites - Between May 1984 and March 1985 radio-collared skunks and raccoons used several types of dens for shelter. Pregnant or lactating females of both species used one den site until the young were mobile. Several den sites were used by individual skunks and raccoons during the summer and fall. Skunks tended to use a single den for winter denning, beginning in late October-early November. However, raccoons utilized more than one site during the winter period and were more active than skunks.

Trees were used almost exclusively by raccoons as den sites in ravine areas (96%), whereas houses were more important in residential areas (40%). Sewer systems in cemetery areas served for denning and foraging (69%). Skunks used burrows under houses and associated structures in residential areas (70%). Ground burrows were extensively utilized in field-ravine areas (80%).

1985 Study

A total of 609 captures was made in the 3 study areas of metro Toronto between 3 June and 2 October 1985. Forty-one different skunks were captured a total of 152 times and 85 different raccoons were captured on 308 occasions. Other captures (plus recaptures) included 90 cats, 49 groundhogs, and 10 miscellaneous animals.

The most notable observation from the trapping data was the difference in relative abundance of raccoons and skunks between the three study areas. Study area No. 1, which consisted of 60% field, 35 residential, and 5% industrial land-use areas, had a considerable population of skunks but very few raccoons (Table 3). Conversely, study area No. 2 had an enormous population of raccoons but almost no skunks (Table 3). The habitat of that area is 60% forested park-cemetery, and 40% residential. Study area No. 3, which had a more diverse land-use of 40% cemetery, 30% residential, and 30% field-forest, had appreciable numbers of both skunks and raccoons (Table 3).

The number of animals varied among study areas and trapping periods. Generally, densities were lowest during the late spring-early summer when primarily adults were present, and highest in late summer-early fall when there were many juveniles (Table 4). Three sizes of live-traps were used. The smallest (#105), captured skunks as frequently as the two larger traps (#106, #108); however, only 11% of the raccoon captures were taken by #105 traps and 97% of those were juveniles. The length of the trapping period (10 days) also revealed valuable information. The majority of different animals ($\bar{x}$ = 87%, range 78-100) captured during 9 nights of trapping were captured during the first 4 nights.

Many domestic cats were at large in metro Toronto. Despite City and Provincial Health Department warnings to keep domestic animals confined in rabies prevalent areas, 90 cats were captured in the 3 study areas (Table 3).

An important finding of this study was the type and frequency of dens utilized by skunks and raccoons. In residential areas, dens associated with houses and their accompanying structures (garages, porches, steps, sheds) were used extensively by both species. However, in ravines and parks, skunks used ground burrows, whereas raccoons preferred trees. We now know where to trap skunks and raccoons for control purposes. The extensive use of residential areas by skunks is also important when considering the potential for transmission of rabies to domestic animals and humans.

The preliminary study also revealed the two species were utilizing just about every type of land-use zone in metro Toronto. Animals were

Table 3. Comparison of feasibility study trapping results among the 3 study areas, June-October 1985.

Trapping Period Date	AREA 1			AREA 2			AREA 3		
	1 June 3 -12/85	2 July 16 -24/85	3 Aug. 26 -Sept. 3/85	1 June 17 -26/85	2 July 29 Aug. 7/85	3 Sept. 10 -19/85	1 July 1 -10/85	2 Aug. 12 -21/85	3 Sept. 23 -Oct.2/85
Trap nights	406	510	404	399	375	406	411	522	531
% Traps tripped	9.4	6.3	8.4	43	40	27	11	16	12
Skunks									
Total captures	7	91	34	2	2	1	4	7	4
Individuals	4	15	13	2	2	1	3	6	4
New captures[1]	4	14	7	2	2	1	3	5	3
Raccoons									
Total captures	2	4	3	37	87	87	24	43	21
Individuals	2	4	3	21	34	32	13	19	11
New captures[1]	2	2	2	21	23	11	13	9	2
Total other captures	48	15	10	6	3	6	29	20	13
cats	13	5	5	4	3	5	27	17	11
groundhogs	33	10	5	0	0	0	1	0	0
misc.	2	0	0	2	0	1	1	3	2
Animals/Trap night									
Including tripped traps	0.14	0.22	0.12	0.11	0.25	0.23	0.14	0.13	0.07
Minus tripped traps	0.16	0.23	0.13	0.20	0.41	0.32	0.16	0.16	0.08

[1]New captures refers to individuals not caught in previous trapping periods.

trapped in fields, ravines, parks, sewer systems, cemeteries and industrial areas, as well as residential areas. If rabies control is to be successful, each land-use type will have to be defined as to location and importance to skunks and raccoons. However, only 3 areas were sampled. Additional trapping in other areas will have to be carried out before abundance levels of skunks and raccoons can be extrapolated for all of metro Toronto.

The very restricted movements and areas utilized by skunks and raccoons as determined from radio-telemetry is important when considering trapping and vaccination as a means of controlling rabies in urban areas. Rabies control will be more effective and less costly if animals are confining their movements to small areas.

Trapping success was greater during May to October than in the late fall and winter. The data suggest at least 3 vaccination periods between June and November will be necessary to vaccinate a high proportion of the population of skunks and raccoons. However, in the current study, several skunk and raccoon home ranges probably overlapped the study areas due to the small size of each area (0.25 km^2). This would account for the "new" animals being captured during each trapping period. In reality, a control program would cover a much larger area encompassing several home ranges, thus reducing the requirement for more than one vaccination period.

The abundance of animals in an area is important when considering control of rabies. Assuming trap-vaccinate-release may be a feasible means of controlling rabies in skunks in metro, knowledge of the abundance of skunks and raccoons is necessary when determining the cost and effort necessary to trap, vaccinate, and release a large percentage of the population. Trapping indicated there are appreciable numbers of skunks in some areas of metro. The problem now lies in determining how to trap them more efficiently by excluding raccoons from the traps. However, we are now capable of selecting skunks over raccoons for capture by using the #105 trap during periods before juvenile raccoons are mobile or after they are too large to enter the trap, an approximate 6- to 8-week period.

Before the feasibility of the control strategy can be assessed on a labor-cost basis, additional studies are needed. Of utmost importance

is the need to extend sampling of human land-use types. Presently, we know which land-use areas support high numbers of skunks and raccoons, but we have not completed sufficient sampling to extrapolate for all of metro Toronto.

Table 4. Relative Abundance of Skunks and Raccoons in 1985 per Study Area per Trapping Period (Density/0.25 km^2 $\pm$ S.E.)*

Density	Trapping Period		
Study Area #1	3-12 June	16-24 July	26 Aug.-3 Sept.
Skunk Density	3.25 $\pm$ 2.2	13.95 $\pm$ 1.4	11.8 $\pm$ 2.7
Raccoon Density	2.0	4.0	3.0
Study Area #2	17-26 June	29 July-7 Aug.	10-19 Sept.
Skunk Density	2.0	2.0	1.0
Raccoon Density	25.4 $\pm$ 6.6	33.8 $\pm$ 5.1	31.0 $\pm$ 4.2
Study Area #3	1-10 July	12-21 Aug.	23 Sept.-2 Oct.
Skunk Density	4.0	8.5 (11.3)	4.0
Raccoon Density	15.9 $\pm$ 5.14	20.4 $\pm$ 4.08	11.7 $\pm$ 3.9

* Density was calculated using the weighted mean method. It is designed to be used as an abundance indicator between study areas only. It cannot be extrapolated as a density estimate for any areas outside the 3 study areas.

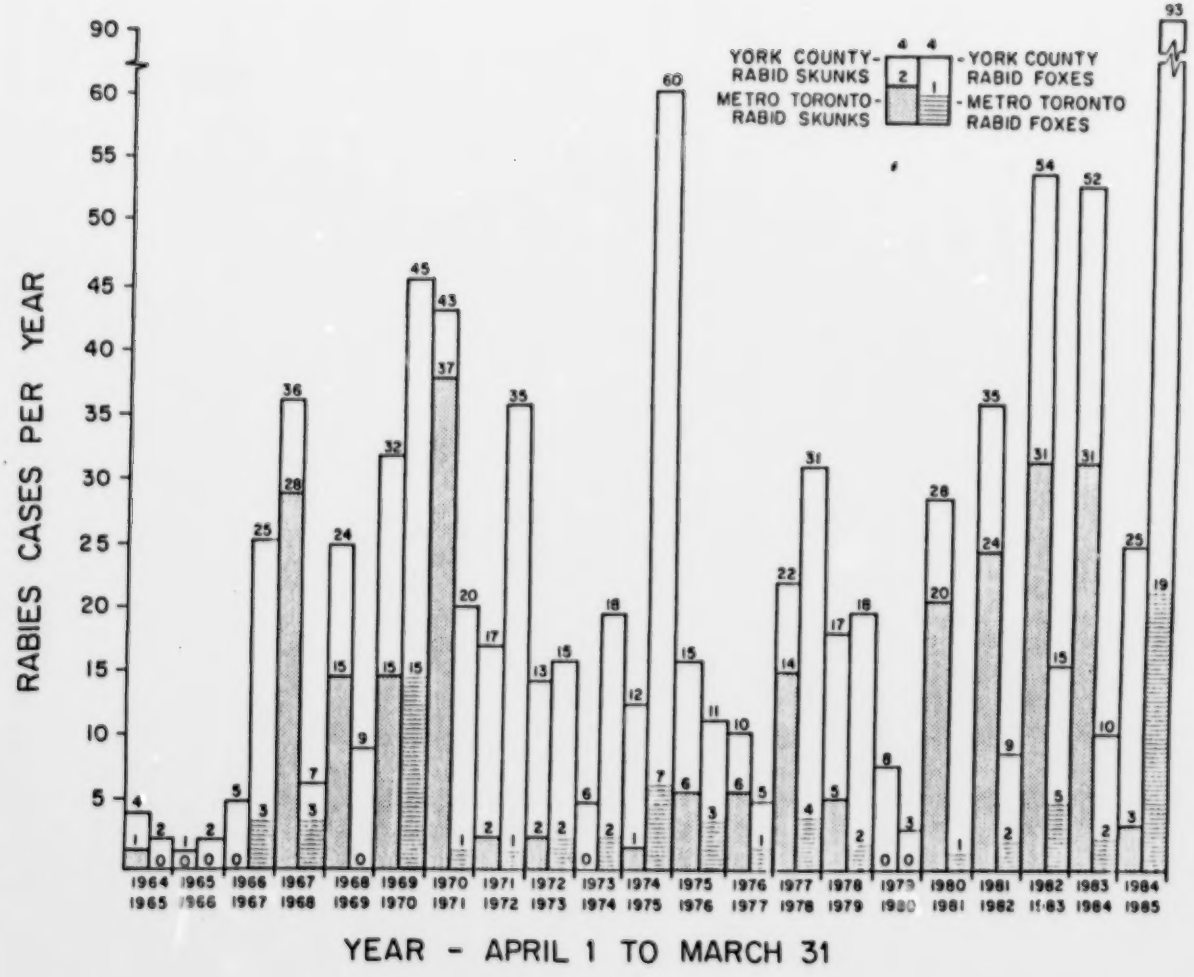

Figure 1. Number of diagnosed rabid skunks and foxes in York County and Metro Toronto 1964-1985.

A Field Trial to Test an Oral Rabies Vaccine in a Bait - P. Bachmann

In a field trial during the fall of 1984 a synthetic bait for a liquid rabies vaccine was tested to determine acceptance by red fox (Vulpes vulpes), striped skunk (Mephitis mephitis), and raccoon (Procyon lotor). No vaccine was in that bait. Only vaccine medium and the biomarker tetracycline was in the bait. Bait acceptance was 64%, 34% and 24% for red fox, striped skunk, and raccoon, respectively.

Based on the promising 1984 results, a similar trial occurred in the fall of 1985. In this trial a rabies vaccine was in the bait. The vaccine was ERA®, a liquid live virus rabies vaccine used in the past for the intramuscular immunization of domestic dogs and cats. Both bait and vaccine were manufactured by Connaught Laboratories Ltd. The purpose of the trial was to evaluate:

1. Bait condition and contact by animals after distribution.
2. Bait acceptance by red fox, striped skunk, and raccoon.
3. Rabies-virus neutralizing antibody formation in the three species.
4. Safety of the vaccine in the three species.
5. Vaccine stability and bait micro-climate.

Study Area, Materials and Method

A detailed description is given in Bachmann et al. (submitted) also found in Wildlife Research Annual Report 1984 (page 45). Descriptions here will be mainly in response to changes in the 1985 trial.

As in 1984, the trial was conducted in a 552 km^2 area in Huron County. The area has been used traditionally for bait trials due to the high density of fox trappers and the large number of foxes harvested.

Bait

The bait was a 4 x 3 x 3 cm cube of flexible polyurethane sponge, coated with layers of histological wax/beef fat, covered with a liver attractant, in an open polyethelene bait bag. A wax strengthening agent, microbond, was added to the coating. There were 100 mg of tetracycline in the wax coating. The coated cube was inoculated with 14

ml of liquid ERA® rabies vaccine and media. The baits were transported to the baiting area in a freezer truck.

Distribution

Baits were distributed from the air in small aircraft (Cessna 172) at one per second, monitored by a metronome. The baits were ejected through the baggage door of the aircraft using 150 mm x 1.25 m PVC tubing. The aircraft flew 130 kph, 100 m above ground.

Towns, houses, farmyards, water and areas within 100 m of roads were not baited. All other habitats were baited. As opposed to the 1984 trial, woodlots and fields with standing corn were baited. Two flight lines along which baits were dropped followed between and parallel to concession roads. Flight lines tended along woodlot edges in the centre of blocks.

Evaluation

1. Bait condition and animal contact: Ground surveys were conducted along flight lines during the first week after baiting. Condition and disappearance of baits were assessed. Contacting animals were identified by tracks near the bait/bait location or bite marks on cubes or bags.

2. Bait acceptance: Red fox, striped skunk, and raccoon carcasses were collected from local trappers. Bait acceptance was the percentage of animals collected from the baiting area with fluorescent tetracycline deposits in their teeth based on microscopic examination of tooth sections (Johnston and Watt 1980). Lines of von Ebner in the dentine of teeth of juveniles were examined for tetracycline fluorescence to determine days on which baits were eaten (Johnston 1975).

3. Rabies-virus neutralizing antibody: Blood-serum was collected from harvested animals to determine immunity rate as a result of oral vaccination. Immunity rate was percentage of animals showing rabies antibody at titre $\geq$ 0.2 IU. Trappers were trained to collect blood samples by cardiac puncture with a vaccutainer of live animals or extraction from the heart with a syringe of dead animals. Serum was extracted after centrifuging blood (3500 RPM for 10 minutes). Serum was analyzed for evidence of rabies antibody with the fluorescent inhibition

microtest (FIMT)(Zalan et al. 1979) and enzyme-linked immunosorbent assay (ELISA) (Thraenhart and Kuwert 1977) by Medical Microbiology and Parasitology Department, University of Toronto.

4. Safety of vaccine: To verify the non-pathogenicity of ERA® live-virus vaccine in the collected animals, brain samples were examined for presence of rabies virus (RV). Samples were taken from the brain stem of each animal in the form of 3cc cores from foxes, raccoons and coyotes, and a 1 cc core from skunks. Heads of animals were saved frozen. Brain cores were screened for presence of rabies virus with the fluorescent antibody test (FAT) (Dean and Abelseth 1973). The brain tissue of all RV+ cores by FAT were examined with the monoclonal antibody technique (MAT)(Wiktor et al. 1980) to determine whether the causative agent was ERA® vaccine virus or a wild rabies virus strain. Salivary glands of ERA®+ specimens by MAT will be examined to determine transmission potential of the virus by biting. All tests were done by the Animal Diseases Research Institute, Agriculture Canada.

5. Vaccine stability and micro-climate: Thirty-six baits with ERA® vaccine, 18 from two different bait lots, were placed outside on the ground to simulate field conditions on September 27. Groups of three baits from each lot were removed on days 0, 3, 7, 10, 14, 28 after placement. Immunizing potency of the vaccine was evaluated over time with the mouse potency test (Habel 1973) on pooled samples of each group removed. Those tests were done by Dr. K.F. Lawson at Connaught Laboratories.

Results

On September 24, 1985 during 8 hours, 10752 baits with ERA® rabies vaccine were distributed in the 552 km^2 baiting area, a density of 19 baits/km^2. Baiting occurred over 576 km of flight lines or 19 baits/km of flight line. Bait densities were similar to 1984: 18 baits/km^2 and 17 baits/km of flight line (Bachmann et al. submitted). Results of bait distribution are shown in Table 1.

Two hundred seventy-nine baits were evaluated during ground surveys. Most baits (84%) were found in habitats where they were easily visible: ploughed areas, stubble fields, pasture and gravel pits. One hundred forty-seven baits (53%) were disturbed by animals. Species were

identified for 100 (68%) of the disturbed baits (Table 2). Baits were most frequently attacked by crows (Corvus brachyrhynchos), foxes and voles/mice (Microtines). Bait bags remained on site in 95% of the disturbed baits, while 18% of cubes or cube portions remained. Of cube/cube portions remaining on site, 93% (N=27) had vaccine in them. Of the undisturbed baits, 9% were chipped or cracked on the wax coating of the cube. In undisturbed baits, non-vaccine liquid was found inside 85% of the bait bags, 32% of bait bags were open, and 59% smelled of liver attractant.

Bait acceptance was higher in red fox than striped skunk or raccoon ($P<0.05$), which were similar ($P>0.05$) (Table 3). The mean and standard error of number of tetracycline lines in teeth of juvenile animals were: red fox, 3.9 ± 0.2 (n=95); striped skunk, 1.3 ± 0.2 (n=15); raccoon, 1.7 ± 0.2 (n=28).

Seventy percent of tetracycline positive juvenile red fox had ingested their first bait at 14 days and 95% of all baits at 28 days (Figure 1). This pattern of bait ingestion in 1985 was similar to the 1984 trial and 1976 trial using deadstock meatball bait (Johnston et al. submitted)($P>0.05$) (Kolmogorov-Smirnov statistic) (Figure 1).

Daily bait ingestion profiles were not determined for striped skunk and raccoon due to small number of juveniles with tetracycline lines.

Serum with positive rabies-virus serum neutralizing antibody (SN+) by FIMT and/or ELISA were pooled for all species. There was no difference in SN+ frequency of antibody positive specimens between the baited area and the control areas in any species ($P>0.05$), whereas there were more tetracycline positive specimens of each species in the baited area ($P<0.05$) (Table 3). Control area 1 was in Huron County within 25 km radius of the edge of the baited area and control area 2 was in the southern Grey County, and northeastern Huron County >25 km from the baited area edge. Percentage positive were similar for red fox and skunk ($P>0,05$), but there were more positive raccoons than either ($P<0.05$)(Table 3). Antibody positive reaction in skunk and raccoon was mainly due to cytotoxicity as a consequence of contamination (L. Barton, University of Toronto, personal communication) (Table 3). As a result of high cytotoxicity in striped skunk and raccoon sera, most samples were suspected to be false-positives and therefore not analyzed

Table 1. Results of bait distribution for eastern and western halves, and entire study area, 1985 trial.

	West	East	Entire Area
Number of baits	6096	4656	10752
Area (km^2)	288(52%)	264(48%)	552
Flight km	336	240	576
Flight km baited	282(84%)	187(78%)	469(81%)
Density - Baits/km^2	21	18	19
- Baits/flight km	18	19	19
- Baits/flight km baited	22	25	23
Distance between baits (m)	46.2±23(SD)	40.6±21(SD)	43.5±22(SD)
Baiting rate (per m)	1/55	1/52	1/54
Time baiting (%)	65	69	67
Distance between roads	1.6	2.0	-

Table 2. Species contacts at 100 of 147 disturbed baits out of 279 baits found in the field, 1985.

Species	Investigated (not eaten)	Part of cube missing	Cube eaten or taken
Crow	7	4	69
Fox	-	-	8
Vole/Mouse	4	3	-
Raccoon	-	3	1
Dog	-	-	1

Table 3. Comparison of tetracycline positive, rabies antibody positives, and titres, serum cytotoxicity, rabid (FAT+) specimens in red fox, striped skunk and raccoon from the baited area (B) and control areas (CL_1, CL_2), 1985.

	Red fox			Striped skunk		Raccoon	
	B	CL_1	CL_2	B	CL_1	B	CL_1
% tetracycline +	64	12	1	33	0	43	2
(n)	(147)	(234)	(166)	(64)	(80)	(108)	(120)
% Antibody +	8	8	7	12	10	31	33
(n)*	(130)	(220)	(131)	(57)	(73)	(70)	(97)
$\bar{x}$ Antibody Titres I.U.	3.0	0.5	3.1	0.3		0.6	
(range)	(0.2-22.3)	(0.2-2.8)	(0.2-22.3)	(0.2-0.7)		(0.2-2.8)	
% Cytotoxic SN+		5		93		91	
(n)		(37)		(14)		(54)	
Number FAT+	1	0	3	1	0	0	0

* Not all carcasses collected generated serum samples.

Table 4. Number of red fox demonstrating rabies antibody in relation to time of first bait ingestion (only those animals which were caught $\geq$ 14 days after first bait ingestion).

Days after baiting	3	4 - 28	0 - 28	>28	Total
Antibody +	2	5	7	1	8
Antibody -	15	36	51	2	53
% Positive	-	12	12	-	13

in relation to bait acceptance. Cytotoxicity was lower in foxes ($P<0.05$) and was not considered a problem (Table 3).

Only juvenile red fox which were caught $\geq$ 14 days after first bait ingestion (via von Ebner-tetracycline positive teeth) were compared to antibody samples (Table 4). Fourteen days are required for antibody to develop after bait ingestion (K. Lawson, Connaught Laboratories Ltd., personal communication). Thirteen percent of those tetracycline positive juveniles were antibody positive (n=61) (Table 4). One juvenile was tetracycline and antibody positive, but was not included because it was caught before the 14 day period. Adult red fox were not included in this analysis because daily lines are not distinguishable in dentine of adults (Johnston 1975). There was no difference in antibody positive between red fox ingesting a first bait on or before day three post-baiting and after day three to day 28 post-baiting ($P>0.05$)(Table 4). Small sample size limits conclusive evidence.

The fluorescent antibody test (FAT) showed that four red fox and one striped skunk were rabid. Three rabid red fox from control area 2 were trapped near the same location; two of those were antibody positive but did not ingest any baits. The rabid red fox from the baited area was antibody negative and did not ingest baits, while the rabid striped skunk from the baited area did ingest a bait, but had no antibody. Monoclonal antibody technique showed that all five rabid animals were carrying a natural wild virus strain, not ERA-virus. Twenty-four rabid specimens (all fox and skunk) collected October-December 1985 by Agriculture Canada in Huron County have shown no ERA-virus pathogenicity. Rabid animals from Huron County will be monitored for ERA-virus until March 1986 (completed results not available at time of printing).

Discussion

Comparisons to the 1984 trial were based on Bachmann et al. (1985). Bait acceptance in red fox and striped skunk in 1985 was similar to 1984 ($P>0,05$). Bait acceptance in raccoon was higher in 1985 than 1984 ($P<0.05$). This significant increase may be attributed to bait distribution in standing corn habitat, a common activity area of raccoon. In all previous trials, bait acceptance by raccoon was always low (Johnston et al. submitted, Bachmann et al. submitted). Standing corn was not baited in these trials. Habitat type baited was recorded during baiting with an electronic logger in 1985. It was found that 29% of the time standing corn was baited in comparison to 26% for woodlot, 38% for all other baitable habitats, and 6% was flown over unbaitable habitat. Baiting of standing corn and woodlots in 1985 did not increase the bait acceptance in red fox or striped skunk. Strategy of baiting areas of standing corn should be implemented if raccoon are the target species.

As in 1984, in 1985 non-target animals, especially crows, had an effect on bait availablility. In 1985 more baits were disturbed by crows than in 1984, while less were disturbed by microtines in 1985 ($P<0.05$)(Table 2). Red fox disturbance was similar in both years ($P>0.05$)(Table 2). Total disturbance rate by animals was similar in 1984, 46% (n=325) and 1985, 53% (n=279) ($P>0.05$). There was no difference in bait damage due to impact with ground between 1984 (16%, n=174) and 1985 ($P>0.05$). It has been suggested that baits with the microbond wax strengthener should be dropped partially thawed (K. Lawson, personal communication). Baits in the 1985 trial were dropped immediately after removal from -20°C. Evaluation of baits in open areas limited animal disturbance information for standing corn and woodlots.

The eastern and western halves of the baited area were baited by different teams, but bait densities were similar for both halves (Table 1). Bait distribution in 1985 was not restricted by differences in habitat type, e.g. standing corn and woodlots, between the eastern and western halves, because all habitats were baited equally. In 1984 there were differences. Times of baiting were similar for both eastern and western halves in 1985 (Table 1) as opposed to 1984. One restriction in the eastern half due to disapproval of baiting on private land: 200

more baits would have been distributed in this half in 1985.

Percent rabies virus serum neutralizing antibody (SN+) in red fox was similar for the baited and control areas ($P>0.05$), while percent ingesting baits was not ($P<0.05$)(Table 3). Those red fox from the control areas that had eaten baits had dispersed from the baited area. Also, 5% (n=481) of all SN+ red fox had not ingested baits. Two of those from the control area 2 were rabid. This indicates presence of natural SN+ antibody due to rabies infection, rabies incubation, or non-fective contact in the red fox population. Antibody titres of the rabid red fox in control area 2 were both lower (0.3 and 2.8 IU) than the mean titre from this area and two other rabid red fox demonstrated no antibody titre (Table 3). The problem: is the antibody in red fox that have ingested baits naturally occurring or vaccine induced? No test is available to distinguish the two antibody types. Indicators may be antibody titres. Mean antibody titres in red fox in the baited area was high in comparison to that of the adjacent control 1 area (Table 3). Both areas were in Huron County which had a relatively low rabies incidence in 1985 (36 rabid red fox). The mean antibody titre of collected red fox from control area 2 was similar to the baited area (Table 3). Control area 2 located within Grey County had a high rabies incidence in red fox in 1985 (181 rabid fed fox) (Rabies statistics from annual Agriculture Canada Reports, 1985). Differences in titres within the same county could indicate vaccine-induced antibody in the baited area. There was no difference in percent SN+ in red fox between 1984 when no vaccine was in the bait and 1985 ($P>0.05$) among the baited and control areas (personal data). But the mean antibody titre in the baited area in 1984 in red fox was 0.7 (n=5) as compared to 0.6 in control area 1 (n=6) and 3.7 in control area 2 (n=8) (personal data). The rabies incidence in red fox in Huron County in 1984 was low (40 rabid red fox) as opposed to Grey (165 rabid red fox)(Agriculture Canada Statistics 1984). There were rabid red fox in the collected animals from 1984; two from the baited area, four from control area 2 (n=112, 113). Only one had antibody titre (=0.4 IU). Differences in titres between 1984 and 1985 could also indicate vaccine induced antibody in 1985 in the baited area.

There was no indication in juvenile red fox with ingested baits

that their was any relationship between antibody titres and number of baits ingested. Similarly there was no indication the red fox trapped later after first bait ingestion had higher antibody titres.

Limitation of ERA® vaccine in the bait was evident by fast drop in potency when in the field (Table 4). A maximum of 60% red fox would show antibody if baits were ingested on or before three days after baiting (Table 5). Twenty-three percent of juvenile red fox ingesting baits did so in the first three days. Therefore, 14% red fox should be SN+. Similarly a maximum of 15% red fox would show antibody if baits were ingested after the three day period after baiting (Table 5). Seventy-two percent ingested baits between three and 28 days; the percent SN+ should be 11%. The calculated values from specimens was 12% for three to 28 days (Table 4). The sample size for ingestion three days after baiting was too small to generate a percent (Table 4). Increasing daily bait pick-up rate or life of vaccine or both will enhance SN+.

Preliminary evidence indicates that ERA® live-virus vaccine was safe in wild carnivores in the study areas.

Production, handling and costs of the 1985 bait was similar to the 1984 bait. The only change in the 1985 bait was the addition of vaccine, a step which was done in 1984 when vaccine-media was added to the bait. The cost of a 14 ml dose of ERA vaccine was $0.56. The 1984 bait without vaccine cost was $0.29/bait and required 0.06 man-hours/bait. The 1985 bait with vaccine and including inflationary factors was $0.86/bait. Mechanization could decrease man-hour costs substantially.

Problems encountered in 1985 were similar to 1984 in relation to bait damage. There was no estimate made on the drop in potency of vaccine in bait with chips or cracks. Drying of contents was not evident from ground surveys. New methods in dropping baits or alteration in bait may enhance bait durability on ground impact.

Temperature may be a factor in vaccine potency. Available data have not been analyzed to give conclusive evidence. Baiting a week or two later may prolong vaccine potency due to lower temperatures.

Limitations to rabies virus neutralising antibody determination were evident due to naturally occurring antibody in populations. This

factor cannot be eliminated. More careful handling may decrease cytotoxic serum of striped skunk and raccoon, however, the exact nature of the cytotoxicity is now known in these species (L. Barton, personal communication). The sponge bait used in this study is a useful method in reaching red fox. Alteration in baits and improvement in vaccines may improve bait ingestion rate and prolong vaccine life as a result increases antibody production by vaccination.

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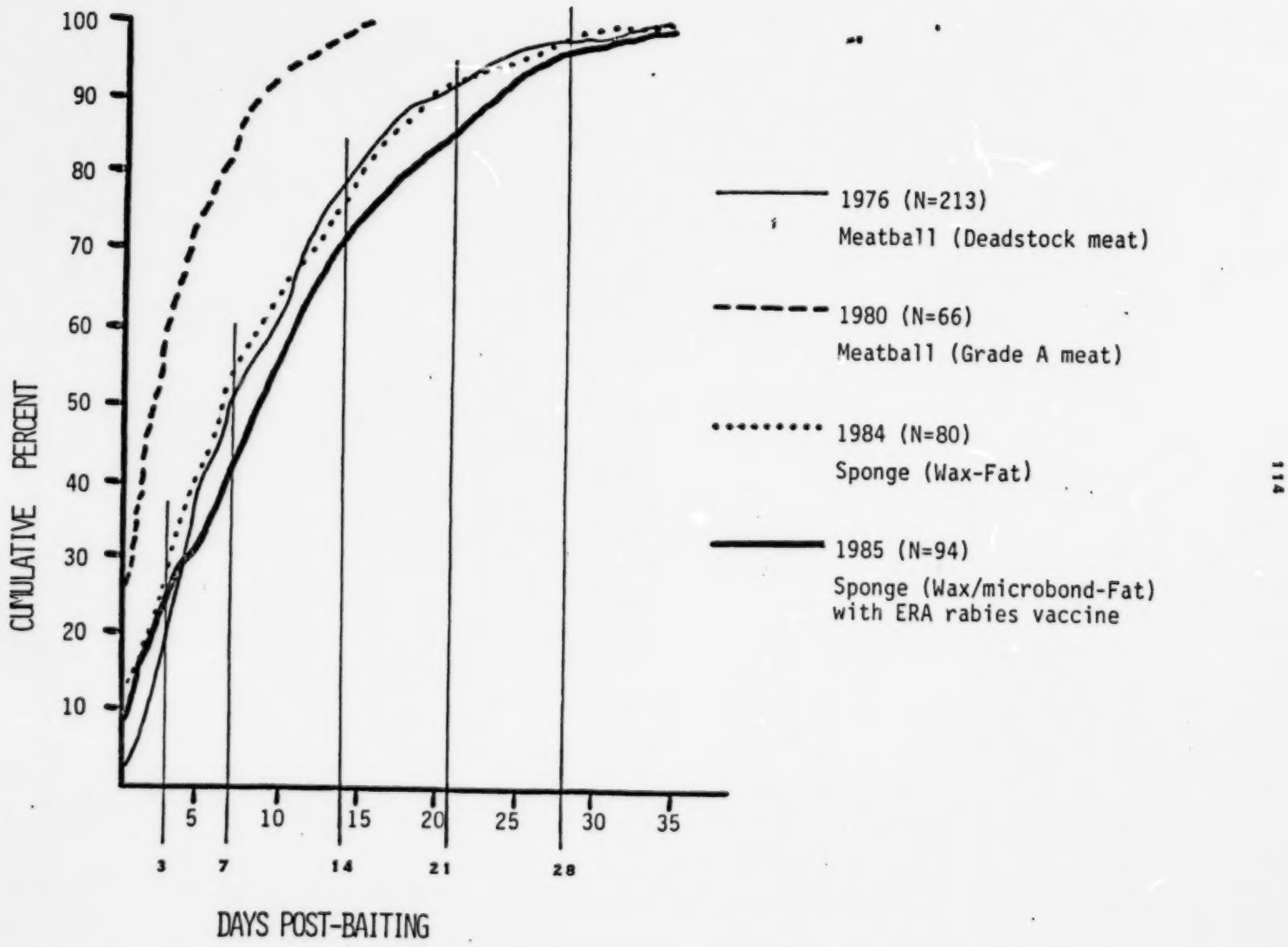

Figure 1. Percent of cumulative frequency of juvenile red foxes ingesting first bait after baiting (based on von Ebner-Tetracycline + lines in dentine of teeth).

RESULTS OF THE 1985 RABIES BAIT TRIAL - C. D. MacInnes

The objective of the 1985 trial was to show that a vaccine, dropped by air in sponge baits, could immunize wild foxes. The trial would integrate, for the first time in our program, results from field experiments to reach foxes with bait, and laboratory studies of vaccine and vaccine-baits.

Safety is of major concern when using live-virus rabies vaccines. Therefore, the Rabies Advisory Committee opted to use a vaccine with a well-established record, even though a more potent product might be desirable. The second objective of this trial was to demonstrate that air-dropped baits were not hazardous to humans, pets or farm animals.

VACCINE

The vaccine used was ERA^R manufactured by Connaught Laboratories. Since ERA^R is no longer marketed, the stock used was made in 1980, and stored frozen, since that time. That vaccine came from five production runs: each batch was handled separately.

Before examining the details of the vaccine, it is essential to understand the titre system used to measure potency. The key is that the titre is expressed as a logarithm. Thus, a titre of 5 is, in real terms, 10^5, and hence a titre of 6 ($=10^6$) is ten times greater than a titre of 5.

Table 1 shows the reactions of foxes fed standard baits each containing 14 ml of ERA^R. This shows that the margin between effective and ineffective vaccine is narrow. One experiment, 5-84, suggests, on limited data, that vaccine deteriorating at field temperatures may be less effective than fresh vaccine diluted to equivalent titres.

Vaccine was reconstituted to make baits for the 1985 field trial. Each batch was tested after being frozen, and baits were held at simulated field temperatures. The resultant titres are in Table 2, together with similar tests conducted in 1984.

In a second test, baits which had been frozen were thawed, and tested for titre. The 1984 baits (5 batches) stored for 18 months, lost only 0.4 (range 0.4-0.8) titre units. The 1985 baits, after only 6 months, lost 0.8 (range 0.4-0.9).

The conclusion is that the 1985 baits lost more titre, more rapidly, than baits tested in 1984. The reason is not clear, but may well be related to details of procedure for freezing the baits after they were filled with vaccine. In 1984, that was done in open trays in a large walk-in freezer. In 1985, the baits had to be sealed in cardboard boxes before being put in the freezer, and so took longer to freeze. All the vaccine used in both years was made in 1980, but tests carried out after thawing frozen vaccine indicate that an additional year in storage did not reduce the titre.

The relation between vaccine titre, strain of vaccine, deterioration at field temperatures, and the ability of vaccine to immunize foxes by mouth is complex. Table 3 shows titrations of the best current candidate vaccine, ERA-BHK21. ERA^R is grown in primary porcine kidney cells, the other variants are grown in BHK-21 cells. ERA-BHK21 is clearly more effective.

Acceptance of baits by target species was encouraging, as results were almost identical to those obtained in 1984 (Table 4). The timing of pick-up of baits by foxes in 1985 was slower than in 1984 (see Figure 1, p.114, 50% by day 7 in 1984, 40% in 1985).

The serum antibody survey showed no statistically detectable result of vaccination (Table 5). There were fewer serum positive animals present in 1984, when no vaccine was dropped, and in the control area in 1985, than in the baited area after use of vaccine in 1985. There were 3 high antibody titres from the 1985 baited area, all foxes which ate a bait before day 5, so we may have vaccinated some foxes, but cannot prove that. Antibody levels were measured by two tests, the FIMT and ELISA. ELISA measures all antirabies antibody present, whereas FIMT measures the ability of the serum to neutralize rabies virus. Results usually correlate well, and differences occur most frequently when only low amounts of antibody are present.

DISCUSSION

Why did the vaccine apparently fail? First we must understand what might have been the best result which could be expected. Table 1 shows that fresh baits should immunize 80% of foxes. By matching results from Tables 1 and 2, and using only information available before

the trial, we can deduce that, after 7 days in the field, some batches of bait should still have vaccinated 50% of foxes eating them, while others would have affected only 15%. Great variability is evident in both tables, producing less confidence in any prediction. Notwithstanding, an optimist would have expected at least 50% of foxes which ate a bait within the first 7 days to show antibody, based on 1984 results. Sixty-four percent of all foxes on the test area ate bait (Table 4), and 50% of those ate their first bait within 7 days after the drop. A combination of these figures (0.50 x 0.64 x 0.50) gives an estimate that 16% of all foxes should have been serum positive. Using 1985 data, with poorer vaccination rate (0.35 vs 0.50) and slower pick-up at 7 days (0.40 vs 0.50) the estimate would be 8.9%. The small number of foxes taken (table 5) makes it impossible to distinguish statistically between the small expected number of vaccinated foxes (8.9%) and the actual number (7.7%) by FIMT.

Why did we proceed, if such a low vaccination rate was expected?

1. The major objective of this trial was to verify that separately developed components of the program did fit together. That is, that a vaccine successful in laboratory experiments would vaccinate foxes in the wild. Clearly in this trial the parts did not fit together, in which case much can be learned by ascertaining why not.
2. There are concerns for the safety of both humans and animals which contact baits containing modified live virus (MLV) rabies vaccine. The second objective of the trial was to verify the safety of the procedure and test public reaction to a product with demonstrable risks. ERA^{R} was therefore an excellent choice of vaccine, because it was in widespread veterinary use for 20 years (by injection, not by mouth).
3. Other candidate vaccines could not be brought through the necessary safety tests in time for a trial in 1985.

The major weak point exposed by this trial concerns the duration of potency of the vaccine. There are two lines of active research, first to find a vaccine with a higher starting titre, and second, to find substances which improve stability under field conditions. Substantial progress has been made on both fronts.

The 1985 baits lost 0.4 titre unit more when thawed than similar

baits subject to experiments in 1984. Since the starting titre of ERA^R is only 0.6-1.0 units above the threshold at which vaccination occurs, that drop was a critical element in the failure. Experiments are in progress to define conditions to freeze the baits much more rapidly after filling. (This may sound simple, but since the vaccine is live rabies virus, the baits cannot be frozen in a commercial facility unless the latter can be completely sterilized before and after).

Another basis for experiments is to shorten the time foxes take to find their first bait. Had we achieved the pick-up schedule of the 1980 experiment (Fig. 1, p.114), the expected rate of vaccination would have increased from 16% to 24%. We are exploring the addition of some Grade A ground beef to the bait package. However, it is not clear whether the 1980 result was due to some characteristic of the 1980 season (e.g. weather after drop, other food resources for foxes, etc.), or to the "fresh" meat. The 1985 trial was a true replicate of the 1984 experiment, from the point of view of pick-up schedule. In that sense it provided very useful information.

The vaccine planned for use in 1986 is ERA grown in a different culture system than ERA^R. This will provide a uniform starting titre of 7.3. Initial tests indicated better than 50% vaccination after 14 days. However, a full round of safety tests is required (most are underway and producing favorable results so far).

Field use of MLV rabies vaccine to immunize foxes began in 1979 in Switzerland, and in 1983 in Germany (Schneider, 1985). Their vaccine has an initial potency in the range of 7.0-7.5. Schneider reports that the Tubingen strain (SAD-B19) retains the ability to vaccinate for at least 14 days. That strain was selected in the laboratory for temperature stability. R.A.C. has requested permission to experiment with the Tubingen strain. Currently, such a preparation could only enter North America via the U.S.D.A. station at Plum Island, MA., where it must be tested for freedom from Foot-and-Mouth virus. The European experience, in which over 1,800,000 vaccine-baits have been used in the field, without incident, has done much to allay fears of North American regulatory authorities about the safety of MLV preparations during field use.

The Germans distribute baits by hand, using hunters, and local

police and forestry staff. We judged that such a labour-intensive system would be too expensive and cumbersome in an area as large as Southern Ontario. Thus, the Ontario scheme may be viewed as an attempt to mass-produce and automate.

THE LONG-TERM FUTURE

A successful MLV rabies vaccine will certainly help reduce rabies in wild foxes. The Swiss claim to have eliminated rabies from substantial areas, or prevented further spread. Schneider's group in Germany have as yet made no claims about changing rabies incidence. However, MLV does not appear to be the ultimate answer. No MLV tested to date has successfully immunized skunks by mouth. RAC is supporting a joint project by Queen's University and Agriculture Canada's Animal Disease Research Institute to develop a product for skunks.

Within the past two years, an exciting new prospect has arisen. Through genetic engineering, the gene for rabies G-protein has been spliced into another virus, vaccinia, which was widely used in the past to protect humans against smallpox. This technology, and the risks associated with it, are described by Moses (1986).
Vaccinia recombinants show great promise for prevention of some human diseases (so far, hepatitis-B, herpes simplex, influenza, and possibly malaria). Therefore, clinical trials to evaluate risk to humans will be conducted by various medical groups. In any case, such investigations would be far beyond the scope of the MNR Rabies Research Program. However, it will probably take at least 3 years to pass judgement on feasibility of using vaccinia recombinants in humans. This is a problem for our program because there is always the possibility of human and animal contact with our baits.

Meanwhile, the Rabies Advisory Committee (R.A.C.) has arranged to have vaccinia-RG (the rabies vaccine) tested on skunks. It works very well, by mouth or by "scratch". Research at the Wistar Institute in Philadelphia has shown that vaccinia-RG is highly effective in raccoons, another species in which MLV rabies vaccines were unsuccessful. Vaccinia readily infects cattle, causing sores.

The R.A.C. has also sponsored an investigation of applying the same technology to a vaccine strain of canine adenovirus (CAV). A

rabies vaccine based on CAV should work in foxes, skunks, and raccoons, all of which are infected by CAV in the wild. Since CAV normally enters its host via the gastrointestinal tract, and is quite hardy and infectious, it should perform much better in bait than MLV rabies. CAV does not infect humans at all.

These high-tech vaccines will require several years to perfect, test and licence. Meanwhile, severe rabies outbreaks continue to plague southern Ontario. Therefore, R.A.C. is putting its major emphasis on quick development of ERA-BHK21, the most likely candidate for a rabies reduction program. Given a successful trial of this vaccine in 1986, more widespread use could begin 1987, leading to a large program as early as 1988. In view of the eventual superiority of the recombinant DNA vaccines, such a program would clearly be an interim measure.

There is public impatience at the slow progress towards reducing rabies in the wild. However, Canada has stringent controls on the licensing of vaccines and drugs. That is a good system, enjoying public confidence. R.A.C. fully supports the objective of this program and most emphatically does not wish to try to circumvent it. In fact, relations with Agriculture Canada's Bureau of Veterinary Biologics are positive and cordial. Therefore, whatever the urgency to get a product into the field, we must emphasize care and safety first. MNR also maintains close contact with OMAF and OMOH, to ensure that they are fully informed, and their concerns are addressed.

The computer simulation model to test vaccination strategies is under intensive development this year. It is providing real insight into what we may expect from control programs. The proposed end-product is a smaller model adaptable to local conditions, which a field manager can use to plan how to get the most rabies reduction for his money.

The Rabies Advisory Committee is supporting a broad range of activities, to ensure that, both in the short-term, and the long-term, Ontario examines the most promising avenues towards control of wildlife rabies.

Moses, P.B. 1986. Vaccinea virus: reinventing the wheel. Bioscience 36:148-150.

Schneider, L.G. 1985 Oral immunization of wildlife against rabies. Ann. Inst. Pasteur/Virol 136:469-473.

Table 1. Experiments 1 - 4 show the proportions of red foxes which developed antibody in response to different titres of fresh ERA^R. Each fox ate one bait, which contained 14 ml of ERA^R. Experiment 5 involves baits which were deteriorating at room temperature.

Experiment and year	No. with antibody/no. in test fed vaccine titre of				
	4.0-4.5	4.5-5.0	5.0-5.5	5.5-6.0	6.0-6.5
1-84					5/10
2-84	4/10		7/9		9/10
3-84					9/10
4-85		1/10		7/10	
Total	4/10	1/10	7/9	7/10	23/30
5-84			0/10	4/10	8/9

Table 2. Titres of vaccine from baits made for the 1985 field trial, and titres after exposure to actual or simulated field temperatures.

Year	Conditions	No. of batches	Number of days at field temperature		
			0	7	14
84[1]	field	5	5.5-6.3	4.0-5.4	<3
85	pre-trial simulated	6	5.5-6.0	4.4-4.8	4.3-5.0
85	trial simulated	2	5.8-6.0	4.6-4.7	4.5-4.9
85	trial field	2	5.3	3.7-4.9	3.9-4.2

Table 3. Proportions of foxes developing antibody after treatment with ERA-3HK21. All vaccine was fresh, and diluted to achieve the titre. Foxes were given 1 bait containing 14 ml of vaccine.

Experiment and year	Titre of vaccine					
	4.5-5.0	5.0-5.5	5.5-6.0	6.0-6.5	7.0-7.5	7.5-8.0
1-85	3/6		6/6		6/6	
2-85		4/6		5/6	6/6	
3-84				10/10		10/10

Table 4. Bait acceptance by target species in the Bayfield study area, 1984 and 1985 trials. Presence of tetracycline (T+) indicates an animal ate a bait. Only animals taken within the 4 weeks after the drop are included.

	1984		1985	
	%T+	N	%T+	N
Fox	64	89	64	75
Skunk	34	56	32	45
Raccoon	24	66	54	28

Table 5. Presence of rabies antibody in serum of red foxes inside and outside the baited area, 1984 and 1985.

Year	Test	Baited area		Control area	
		Number positive	Total	Number positive	Total
1984	ELISA	6	108	12	176
	FIMT	3	110	7	180
1985	ELISA	10	130	24	351
	FIMT	7	130	8	351

Meetings, Lectures and Seminars

E.M. Addison

January 2 - Lecture on moose research topics to International Moose Symposium, Maple.

January 11 - Seminar "Status of Eurasian moose populations", Maple.

January 23 - Lecture "Effects of winter ticks on moose" to Michigan DNR Staff, Algonquin Park.

February 5 - Lecture "Moose - winter tick research progress" to Wildlife Club, University of Guelph.

February 8 - Seminar "Impact of high moose numbers in Sweden", Maple.

February 12 - Lecture "Parasites and diseases of furbearers", Trapper's Education Course, Seneca College.

February 15 - Seminar "Moose Management and Hunting Techniques in Fennoscandia", Maple.

February 26 - Presented two lectures to School of Forestry, Lakehead University. (1) Moose-forest interactions in Sweden, (2) Moose-winter tick research - Progress report.

February 28 - "Second International Moose Symposium", Regional Fish and Wildlife Seminar, Kenora.

March 4 - Lecture "The Private Life of the Moose" Toronto Field-Naturalist Club, Toronto.

March 2 - Lecture "Effects of winter ticks on moose", Kingston Fish and Game Club, Kingston.

March 7 - Lecture "Relationship between moose and winter ticks", Ontario Parasitology Club, McMaster University, Hamilton.

March 20-21 - Presented talks to MNR district staff in Cochrane (1) Political causes and impact of increases in Scandanavian moose, (2) MNR research on the health of moose, and (3) Moose calving and calf productivity in Algonquin Park.

July 12 - Three lectures to Fish and Wildlife Certificate Course, Algonquin Park. (1) Parasites and diseases of furbearers, (2) Parasites and diseases of deer and moose, (3) Research program on health of moose.

August 27 - Seminar "Comparisons of moose populations and management in Sweden and Ontario", Northeastern Region Fish & Wildlife staff, Halfway Lake Provincial Park.

September 13 - Seminar "Comparisons of moose populations and management in Sweden and Ontario" , Central Region Fish & Wildlife Staff, Camp Borden.
September 27 - Two talks to Moose Hunter Information Session, Thunder Bay. (1) Common parasites and diseases found in moose, (2) Ten years of moose research in Ontario.
October 3 - Talk "Impact of winter weather and ticks on the health of moose", Sydenham Sportsmen Association, Owen Sound.
October 5 - Talk "The private life of the moose" ,Toronto Junior Field Naturalists Club, Toronto.
November 1 - Talk "Effects of winter weather and ticks on moose", Bracebridge Rotary Club.

P. Bachmann

January 18 - Rabies presentation to Windfield Farms Staff, Oshawa.
February 3 - Rabies presentation to Niagara Trappers Council, Williamsport.
February 4 - Rabies presentation (Ecology) to York University Environmental Studies Graduate students at Maple.
February 6 - Rabies presentation to Mohawk College Fur Harvest, Management and Conservation Course, Westover.
February 7 - Rabies presentation to Georgian College Fur Harvest, Management and Conservation Course, Owen Sound.
February 11 - Rabies presentation to Georgian College Fur Harvest, Management and Conservation Course, Owen Sound.
March 6 - Rabies presentation (Vector Ecology and Baiting) to 3rd year Fish and Wildlife Technology, Sir Sandford Fleming College, Lindsay.
March 18 - Rabies CBC movie and presentation (Fox and Coyote Biology) to 2nd and 3rd year Bioloby, University of Toronto, Scarborough.
March 19 - Rabies presentation (Fox and Coyote Biology) to Seneca College Fur Harvest, Management and Conservation Course, King City.
November 5 - Rabies presentation to Conestoga College Fur Harvest, Management and Conservation Course, Clinton.
November 10 - Rabies presentation (Baiting Update) to Huron County Trappers Workshop, Hullett WMA, Clinton.

D.J.T. Hussell

January 24 - Attended meeting of Technical Advisory Committee, Ontario Breeding Bird Atlas, Toronto.

January 29 - Attended meeting of Data Review Subcommittee, Ontario Breeding Bird Atlas, Toronto.

March 20 - Attended meeting of Trustees of James L. Bailie Memorial Fund for Bird Research and Preservation, Toronto.

March 23 - Attended general meeting of the Ontario Breeding Bird Atlas, Peterborough.

March 27 - Seminar "Update of the Canonto Deer Study Analysis", Wildlife Research Section Seminar Series, Maple.

April 25 - Attended meeting of Data Review Subcommittee, Ontario Breeding Bird Atlas, Toronto.

July 18 - Lecture "Canonto Deer Study Analysis" to Fish and Wildlife Certificate Course, Dorset.

September 12 - Seminar "Analysis of the Canonto Deer Study Data: Does Hunting Mortality Affect Future Population Levels?" at Wildlife Technical Meeting, Dorset.

September 26 - Attended meeting of the Trustees of the James L. Baillie Memorial Fund for Bird Research and Preservation, Toronto.

October 7-10 - Attended meeting of American Ornithologists' Union, Tempe, Arizona and presented paper:"Food abundance and clutch size in Tree Swallows" with T.E. Quinney.

October 16 - Attended meeting of Publication Committee, Ontario Breeding Bird Atlas, Toronto.

October 17 - Attended meeting of the Data Review Subcommittee, Ontario Breeding Bird Atlas, Toronto.

October 26-17 - Attended meeting of Trustees of the North American Loon Fund, Gilford, New Hampshire, U.S.A.

November 11 - Attended meeting of the Technical Advisory Committee, Ontario Breeding Bird Atlas, Toronto.

November 13 - Attended meeting of Publication Committee, Ontario Breeding Bird Atlas, Toronto.

December 18 - Attended meeting of the Program Committee of the Long Point Bird Observatory, Toronto.

December 27 - Attended meeting of the Program Committee of the Long

Point Bird Observatory, Dundas.

G.B. Kolenosky

January 9 - Seminar "Tagging Polar Bears in Ontario, Techniques and Progress", Wildlife Research Seminar Series, Maple.

January 14 - Lecture "Black Bear Ecology and Management", Humber Gun Club, Malton.

January 16 - Lecture "Polar Bear Ecology and Ontario Tagging Program", Student Chapter of Wildlife Society, University of Guelph.

February 11-15 - Participated in Federal-Provincial Polar Bear Technical Committee Meeting, Edmonton, Alberta.

April 25 - Presented two talks on "Wolves and Polar Bears" to staff and students of Parkview Secondary School, 45 Felstead Avenue, Toronto.

June 10 - Participated in Ontario Polar Bear Research and Management Group Meeting, Timmins.

June 25-26 - Participated in Animal Handling Course presented to NE Region Field Staff, Windy Lake Provincial Park.

November 26 - Lecture "Polar Bear Research and Management in Ontario", Central Region Staff, Maple.

H.G. Lumsden

January 24 - Attended Breeding Bird Atlas meeting at F.O.N., Toronto.

February 4-7 - Attended Wing Bee with Canadian Wildlife Service in St. Foy, Quebec.

February 11-14 - Attended Mississippi Flyway Technical Section meeting, Kansas City, Missouri.

February 15-17 - Attended 5th International Waterfowl Symposium, Ducks Unlimited.

February 19 - Seminar "Trumpeter Swan Reintroduction Program", Wildlife Research Seminar Series, Maple.

March 2 - Attended Breeding Bird Atlas Meeting, Maple.

March 9 - Lecture "Trumpeter Swan Reintroduction", Ontario Bird Banders Association.

March 22-23 - Attended Breeding Bird Atlas Coordinators meeting, Trent University, Peterborough.

March 25 - Attended Goose and Gull Committee Meeting, Metro Parks,

Toronto.
April 21 - Lecture "Trumpeter Swan Reintroduction", Viewing Day at Tiny Marsh.
April 30 - Attended annual meeting of Niska Wildlife Foundation and Kortright Park.
June 21 - Attended Gull Symposium, Toronto.
July 27 & 28 - Lecture "Ontario's Trumpeter Swan Program", Technical Section and Atlantic Flyway Council.
July 26-29 - Attended Atlantic Flyway Council Meeting Cherry Hill, New Jersey.
September 21-22 - Attended Trumpeter Swan Society Director's meeting, Maple.
November 4 - Lecture "Trumpeter Swan Program", Faculty of Forestry, University of Toronto.
December 2 - Attended meeting with Canadian Wildlife Service, Toronto.
December 11 - Attended Breeding Bird Atlas meeting, FON, Toronto.

C.D. MacInnes

February 28 - Attended Rabies Symposium, Ottawa.
March 20 - Attended Rabies Symposium, Toronto.
May 6 - Attended Rabies Information Meeting, Goderich Township.
May 7 - Attended Rabies Information Meeting, Hullett Township.
May 14 - Attended Rabies Information Meeting, Tuckersmith Township.
May 28/29 - Attended COJFRC Meeting, Batchewana Bay, Sault Ste. Marie.
June 6 - Lecture "Rabies" to Bayview Secondary School students.
June 18 - Attended Rabies Information System, Colbourne Township.
July 18 - Lectures "What is Wildlife Research", "The Polar Bear Project", and "Radiotelemetry in Research and Enforcement" to Wildlife Certificate Course, Dorset, Ontario
August 13 - 20 - Attended IVth International Theriological Congress in Edmonton, Alberta.
August 27 - Presented paper "Wildlife Reaction to Forest Sites" to COJFRC Meeting in Timmins, Ontario.
November 13 - Lecture "Prevention of Rabies in Ontario Wildlife" to Forestry Class, University of Toronto.
November 25-27 - Attended Annual Conjoint Disease Meeting, Toronto.

November 28 - Attended COJFRC Meeting, Toronto.

R.C. Rosatte

January 31 - Attended Media Communications Workshop, Toronto.
February 4 - Presentation "Urban Rabies Control" to York University students.
March 20 - Presentation "Urban Rabies Control" to Metro Toronto Rabies Symposium.
November 26 - Presentation "Feasibility of Urban Rabies Control" to 53rd Conjoint Meeting on Infectious Diseases, Toronto.
December 3-5 - Presented 2 papers: (1) "Preliminary Studies on the Feasibility of Urban Rabies Control", (2) The Use of Population Reduction for Rabies Control" to 7th Great Plains Wildlife Damage Control Workshop, San Antonio, Texas.
December 12 - Presentation "1986/87 Urban Rabies Project" to Rabies Advisory Committee Meeting, Toronto.

D.R. Voigt

January 21 - Meeting on Forest-Wildlife Conference and Modelling Workshop, Queen's Park.
January 31 - Lecture on "Cooperative Deer Study" at N.E. Region Fish and Wildlife Technical Meeting, Sudbury.
February 18 - Lecture on "Fox and Coyote Biology" to Quinte Sporting Dog Association, Belleville.
February 19 - Media briefing on Cooperative Deer Study, Huronia District, Midhurst.
February 20 - Wildlife Branch briefing on "Why Sweden Has More Moose Than Ontario."
February 22 - Presentation at Annual Meeting of Ontario Federation of Anglers and Hunters, Sault Ste. Marie, on "Why Sweden Has More Moose Than Ontario."
March 13 - Lecture on "Rabies Research in Ontario" to the Wildlife Society, University of Guelph.
April 10-11 - 1st Cooperative Deer Study Workshop, Huronia District.
April 16 - Meeting with Queen's University re Ontario Rabies, Kingston.
April 22-23 - Meeting re Cooperative Deer Study, Rondeau Provincial

Park, Chatham District.

June 11 - Telemetry Tour for Chinese Science Delegates, Huronia District.

June 21 - Lecture on Cooperative Deer Study, Algonquin Regional Fish & Wildlife Technical Meeting, Huntsville.

June 24-26 - Course given on Animal Handling and Capture with Kolenosky for N.E. Regional staff, Sudbury.

July 18 - Lecture on "Cooperative Deer Study" for Fish and Wildlife Certificate Course, Dorset.

July 24-26 - 2nd Cooperative Deer Study Workshop, Loring Deer Station, North Bay District.

August 7 - Meeting with Queen's University re Ontario Rabies, Kingston.

August 12-20 - Attended IV International Theriological Congress, Edmonton, Alberta. Presented Poster at Carnivore Symposium on "Differences Among Red Fox Families in Ontario." Attended Canid Specialist Meeting.

September 10-12 - Attended Biologists' Technical Meeting, Dorset.

September 26 - Meeting with Queen's University re Ontario Rabies, Kingston.

October 17-19 - Attended Great Lakes Deer Group Meeting, Marquette, Michigan. Presented: 1) Deer Management Update for Ontario, 2) Black Bear Management Update for Ontario, and 3) Cooperative Deer Study Lecture.

November 6 - Meeting with Queen's University re Ontario Rabies, Kingston.

November 26 - Lecture on "Development of an Ontario Rabies Model" for Disease Control at Annual Conjoint Disease Meeting, Toronto.

December 10-12 - 3rd Cooperative Deer Study Workshop, Rondeau Provincial Park, Chatham District.

December 16 - Attended meeting of Program Committee for Ontario Boreal Forest at Wildlife Technical Workshop, Queen's Park, Toronto.